Spark Spectral Sensor
User Manual

For Products: Spark-VIS, Spark-OEM-VIS, Spark-DET-VIS
Document: 911-00000-000-02-201504

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About This Manual

Document Purpose and Intended Audience

Thank you for choosing Ocean Optics! We hope that you'll be delighted with your decision. This document provides the users of Spark spectral sensors with instructions for setting up, calibrating and performing experiments with their device. It also contains detailed technical specifications and information about firmware and hardware integration. If you can't find what you're looking for in this document, please do not hesitate to contact us at techsupport@oceanoptics.com or via www.oceanoptics.com.

Document Summary

Chapter	Description
Chapter 1: *Introduction*	Introduces the product features. Contains descriptive information about the Spark and its accessories. Gives an overview of features, applications and specifications for all users.
Chapter 2: *Installation and Setup*	Provides installation and set-up instructions for users of the Spark-VIS product.
Chapter 3: *Spark Operation with OceanView*	Outlines how to make measurements with OceanView software.
Chapter 4: *Troubleshooting*	Covers commonly encountered user difficulties.
Chapter 5: *Technical Specifications*	Contains an overview of specifications and product mechanical diagrams.
Chapter 6: *Calibration*	Contains details on calibration.
Chapter 7: *Firmware and Advanced Communications*	Provides details on advanced communication protocol through USB for Spark-VIS.
Chapter 8*: Spark-OEM-VIS and Spark-DET-VIS Advanced Use*	Gives connection and specification details on OEM and DET devices. Offers additional data for ELIS detector, circuitry and electronic specifications.

Product-Related Documentation

You can access documentation for Ocean Optics products by visiting our website at http://www.oceanoptics.com. Select Support → Technical Documents, then choose the appropriate document from the available drop-down lists.

Document for…	Document Location
OceanView software	http://oceanoptics.com/wp-content/uploads/OceanViewIO.pdf
Device driver issues	http://oceanoptics.com/wp-content/uploads/Correcting-Device-Driver-Issues.pdf

Ocean Optics offers a Glossary of spectroscopy terms to help you further understand your state-of-the-art products and how they function, located at: http://oceanoptics.com/glossary/.

Document Version

Document Number	Version
911-00000-000-02-201504	First release

Warranty

Our 3-Year Warranty covers Ocean Optics miniature fiber-optic spectrometers, spectral sensors, light sources and sampling accessories – regardless of the application – from manufacturing defects. It also covers fibers and probes for a full 12 months: http://oceanoptics.com/services/exclusive-3-year-warranty/.

This comprehensive warranty ensures you of the highest level of craftsmanship and reliability for years to come. No other manufacturer offers such a solid guarantee of quality and reliability. The Ocean Optics 3-Year Warranty applies to Ocean Optics equipment (excluding OEM configurations) purchased on or after July 1, 2010. The warranty covers parts and labor needed to repair manufacturing defects that occur during the warranty period. We also will cover the costs of shipping warranty-related repairs from our customers to Ocean Optics and from us to our customers.

ISO Certification

Ocean Optics, the industry leader in miniature photonics, has been certified for ISO 9001:2008 certification applicable to the design and manufacture of electro-optical equipment since 2009.

Compliance

WARNING

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

FCC COMPLIANCE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which the user will be required to correct the interference at his own expense.

WARNING: The authority to operate this equipment is conditioned by the requirement that no modifications will be made to the equipment unless the changes or modifications are expressly approved by the manufacturer.

Chapter 1

Introduction

Product Introduction

The Spark spectral sensor is the first Ocean Optics spectral device to make use of a solid-state optical sensor in place of the diffraction gratings normally seen in our spectrometer product range. This change has enabled Ocean Optics to reduce the footprint of a miniature spectral device down to the size of an electronic component, and to do so for a competitive and accessible cost.

Spark comprises a family of spectral sensor products and is available in three formats – a core spectral sensor product and two embeddable, OEM-friendly versions – with the level of integration up to the customer. The Spark-DET, the smallest version, is at the heart of the plug-and-play core device (both shown below), and, weighing less than 1g, the Spark-DET is the smallest spectral device on the market.

A spectral sensor is a new class of device that focuses on size, manufacturability, and value, bringing the power of spectroscopy to the sensor market. The Spark also offers users full spectral information in applications previously dominated by RGB photodiode devices.

Spark Spectral Sensor – Spark and Spark-DET

The benefits to the customer are huge: the Spark's small footprint allows for a wide range of applications – integration into hand-held devices, on-line process monitoring, mounting on UAVs – and its low cost brings the power of spectroscopy both to the bulk market and to the individual user.

The Spark is capable of detecting light in the 380 to 700 nm wavelength range making it ideal for color, absorbance and fluorescence measurements in both educational and industrial environments.

This novel technology will allow our customers to explore a previously inaccessible world of spectroscopy measurements. We are eager to find out where you go and what you are able to do with this revolutionary device!

Product Features and Applications

Feature	Specification	Good for…
Visible wavelength range	380 to 700 nm	Color, PAR, fluorescence, and absorbance measurements
Highly compact	15g including electronics, 3.8g without electronics, <1g for detector	Integration into handheld and portable devices or onto process lines
Thermally stable	-10 to 60 °C operating range	Analysis in harsh environments
High resolution	4.5 to 9.0 nm (~1.2% across range)	>80 element color measurements
Fantastic value	Our lowest cost spectral sensor	Accessibility for high volume or cost-constrained applications
Ease of use	Spark-VIS plug-and-play with micro-USB connectivity	Education, remote control on UAVs and new applications

For more information on applications, or for a little inspiration, please visit our Applications page at http://www.oceanoptics.com/application/.

Specifications[AG1] Summary

Specification	Spark-VIS	Spark-OEM-VIS	Spark-DET-VIS
Spectroscopic			
Spectral Range	380 to 700 nm		
Optical resolution	4.5 to 9.0 nm FWHM (~1.2% wavelength)		
Signal-to-noise ratio	1500:1		
Stray light	~0.3 to 1% across range		
Electronic			
A/D resolution	14 bit	N/A	
Power consumption	250 mA @ 5 VDC	30 mA @ 5 VDC	
Connector	micro-B USB (power and signal)	12-pin (0.5 mm pitch) ribbon cable	14-pin (7 x 2) connector
Detector			
Detector	Panavision ELIS1024 linear silicon CMOS array		
Integration time	10 µs to 10 s		
Pixels	1024		
Physical			
Operating temperature	-10 to 60 °C		
Relative humidity	0 to 85 % (non-condensing)		
Dimensions (L x W x H)	53.3 x 36.4 x 19.9 mm	38.4 x 22.6 x 10.2 mm	18.42 x 9.65 x 9.53 mm
Weight	15 g	3.8 g	<1 g

Product Versions

Spark-VIS	Spark-OEM-VIS	Spark-DET-VIS
Core product Plug-and-play via micro-USB Accessories available	**OEM product** Requires driver and communication electronics Ribbon cable connector with raw analogue output Accessories available	**Detector (high volume only)** Requires embedding into custom electronics and housing Contact our Sales Team to discuss integration opportunities
Education R&D Application testing	OEM/custom solutions Medical devices Process monitoring	High volume integration Handheld devices Embedded systems

Chapter 2

Installation and Setup

What's In the Box

- **Spark spectral sensor**

  The Spark-VIS and Spark-OEM-VIS products can be ordered individually with the items specified below. The Spark-DET-VIS product may only be ordered in volume for OEM applications – it would therefore not be shipped with any components other than the Packing List (below).

- **Packing List**

  The packing list is inside a plastic bag attached to the outside of the shipment box (the invoice arrives separately). The packing list includes the shipping and billing addresses, as well as any items on back order.

- **Micro-USB Cable (for Spark-VIS format only)**

  Use this cable (CBL-MICROTOA-USB) to connect your spectral sensor to a computer running on a Windows, Mac or Linux operating system (USB Type A to Micro-B).

- **Calibration Data Sheet (for Spark-VIS and Spark-OEM-VIS only)**

  Each Spark-VIS and Spark-OEM-VIS spectral sensor is shipped with a Wavelength Calibration Data Sheet that contains information unique to your device. OceanView reads this calibration data from your Spark when it interfaces to a computer via the USB port.

Note

For the Spark-VIS and Spark-OEM-VIS products, please save the Wavelength Calibration Data Sheet for future reference.

Spark Installation

The following procedure provides general instructions for getting your new Spark spectral sensor up and running.

Caution

On the first occasion that the software is installed, and the first time the Spark is connected to the computer, the computer must be connected to the Internet. Once the driver software has successfully installed for both the software and the device, both products will work offline.

Be sure to install the software BEFORE connecting the Spark to your computer. The software installs the drivers required for spectral sensor installation. If you do not install the software first, the system will not properly recognize the unit.

If you have already connected the Spark to a computer running on a Windows platform prior to installing the operating software, see Chapter 4: *Troubleshooting* for information on correcting a corrupt Spark installation.

► ***Procedure***

1. Install your spectroscopy operating software by following the installation wizard prompts. See *Software Installation* for more in-depth information.
2. Locate the micro-B USB cable provided with the Spark. Connect the spectral sensor to the USB port on your computer using this cable. See *Hardware Setup* for more in-depth information.

You will find more information about using the Spark with OceanView in Chapter 3: *Spark Operation with OceanView*. For more detailed information please see the OceanView manual (see *Product-Related Documentation*).

Software Installation

The Spark is designed to work with OceanView 1.5 and above. It is not compatible with SpectraSuite or older software. You can use OceanView on the following operating systems.

Software / OS	Windows						Apple	Linux
	2000	XP	Vista	7	8	8.1		
OceanView		√	√	√	√	√	OS X Version 10.5 or later on Intel processor	Any version released for an x86 or amd64 platform since 2010

Note

Your computer must be connected to the Internet while the software is being installed. For advice on how to install software while offline, please contact our Technical Support team.

About OceanView

OceanView is the latest generation of operating software for all Ocean Optics spectral devices. It is a Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems. The software can control any Ocean Optics USB device.

OceanView is a user-customizable, advanced acquisition and display program that provides a real-time interface to a variety of signal-processing functions. With OceanView, you have the ability to perform spectroscopic measurements (such as absorbance, reflectance, and emission), control all system parameters, collect and display data in real time, and perform reference monitoring and time acquisition experiments. Consult the OceanView manual for hardware requirements when using OceanView (see Product-Related Documentation).

Hardware Setup

The Spark spectral sensor connects to a computer via the USB port. When connected through a USB 2.0 port, the spectral sensor draws power from the host computer, eliminating the need for an external power supply. The Spark-VIS, like all Ocean Optics USB devices, can be controlled by our OceanView software. This is a Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems.

► ***Procedure***

Follow the steps below to connect the Spark to a computer via the USB port:

1. Install the spectral sensor operating software on the destination computer.
2. Locate the micro-B USB cable provided with the Spark.
3. Insert the micro-B connector end of the cable into the side of the Spark. Insert the larger, USB Type A, end of the cable into the USB port of the computer.
4. Connect any Spark accessories (see Available Accessories).

Your computer must also be connected to the Internet the first time that the Spark is plugged into the computer, to install the driver files. If this is not possible, see Chapter 4: Troubleshooting.

Note

The driver files may take several minutes to install. The driver will only load if the computer is connected to the Internet and the time taken to install these files will depend on Internet connection speed.

If you installed the spectral sensor operating software prior to connecting the Spark, the software automatically installs the Spark drivers. If the drivers do not successfully install (or if you connected the Spark to the computer before installing the software), see Chapter 4: Troubleshooting.

Available Accessories

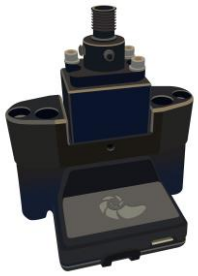
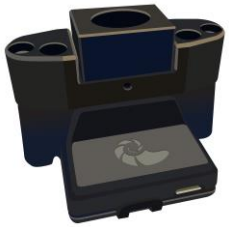
Ocean Optics provides a range of sampling and light source accessories. Accessories specifically designed for the Spark are described here; they are not provided with the Spark spectral sensor and must be purchased separately. See Measurement Techniques – Typical Set-ups for more information on using accessories with Spark. Visit us at www.OceanOptics.com for a complete list of products available for all of your spectroscopy needs.

Spark Accessories

The Spark and Spark-OEM have points to mount them onto a bench or a surface compatible with M2.5 bolts or screws (the mounting points are not threaded). The Spark may be mounted towards or away from the surface, depending on the sample location. These points can be used to simultaneously connect to a range of dedicated accessories for the Spark.

Note

All accessories can only connect to the Spark or Spark-OEM via the Base accessory (part number SPARK-ACC-BASE). The Base accessory is compatible with both of these product models.

Spark Base Accessory – SPARK-ACC-BASE	
	• Interface between Spark or Spark-OEM and *all other accessories* – this part is compatible with both product formats • Connected to Spark or Spark-OEM with two M2.5 screws (provided), connected to Spark accessories with inbuilt twin magnets • Contains filter holder for 0.5” filters (filters themselves sold separately)
Spark SMA Adapter Accessory – SPARK-ACC-SMA	
	• Magnetically attached to Spark or Spark-OEM via Base accessory (SPARK-ACC-BASE, sold separately) • Couples to SMA905 optical fibers • Can fiber couple to all existing Ocean Optics sampling accessories and light sources
Spark Diffuser Accessory – SPARK-ACC-DIFFUSER	
	• Magnetically attached to Spark or Spark-OEM via Base accessory (SPARK-ACC-BASE, sold separately) • Recommended for free-space measurements

Light Sources and Other Accessories

Ocean Optics supplies a large range of other accessories for use with all of our spectral sensors and spectrometers. These are all fiber-coupled accessories, and therefore you may only connect these to the Spark via the SMA Adaptor accessory (part number SPARK-ACC-SMA, sold separately). These accessories include:

- Fibers
- Light Sources
- Integrated Sampling Systems
- Cuvettes, including microfluidic cuvettes
- Filter holders and filters, including low pass, band pass, and high pass

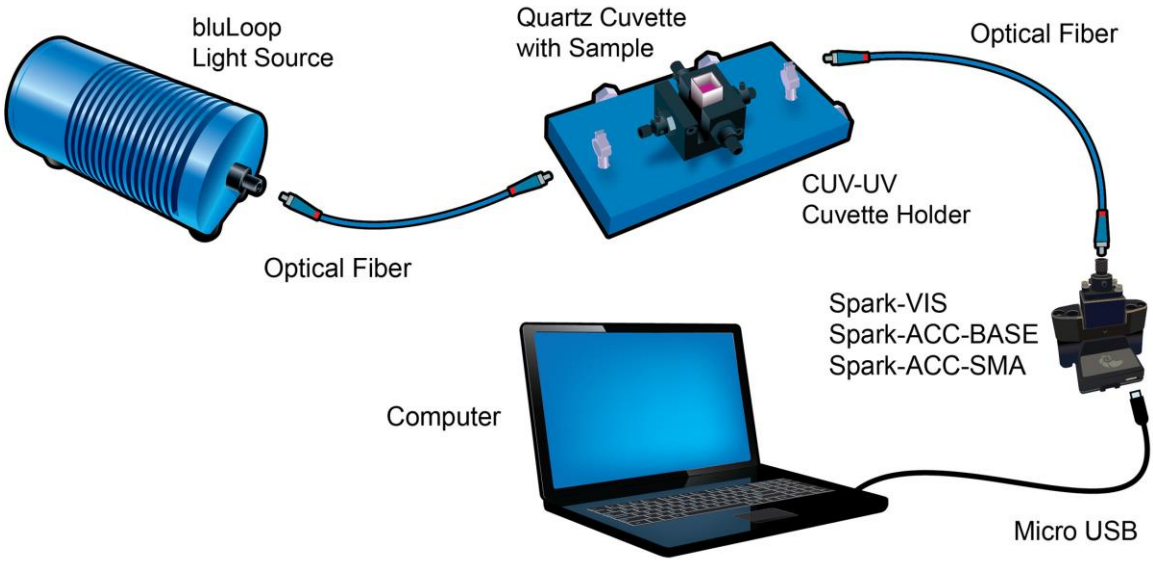
For advice on which accessories may be required for your application, or for help in ordering these parts, please contact Ocean Optics.

Measurement Techniques – Typical Set-ups

The Spark, in conjunction with Ocean Optics light sources and sampling accessories, can be used for many different measurement techniques. One of the key advantages of modular fiber optic spectroscopy is that you can change components of the system without having to buy a whole new system. Here, we show a range of typical visible set ups for basic spectroscopy techniques. You'll find lots more information about measurement techniques at www.oceanoptics.com/measurementtechnique.

Absorbance

Absorbance is typically a relative measurement, comparing the spectrum from the sample to that of a reference. Absorbance is commonly used for concentration measurements and for identifying components in mixtures. Connect the Spark to our cuvette accessories via the SMA Adaptor accessory to take a liquid sample Absorbance measurement, or mount it directly against the sample with a light source on the opposite side for solid sampling.



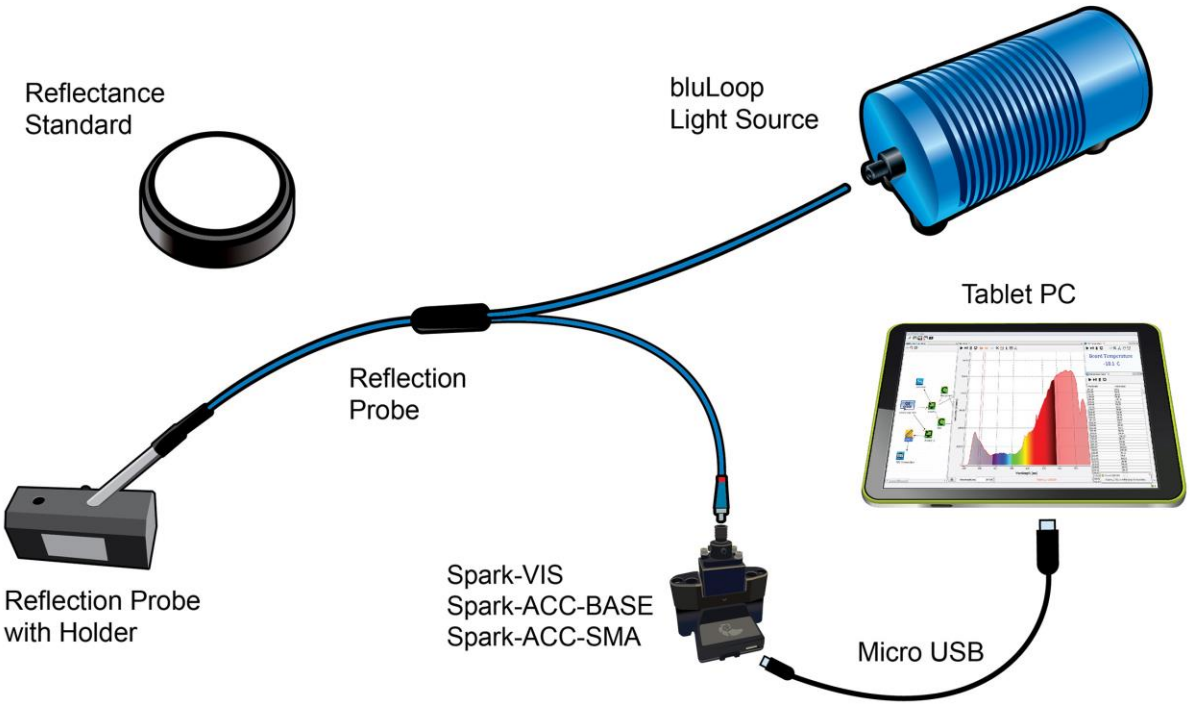
Typical Absorbance Set Up

Common Absorbance Applications

- Quantification of proteins in life science samples
- Environmental monitoring of water impurities
- Analysis of chemical composition of mixtures

Reflectance & Transmission

Reflectance spectroscopy compares the relative level of light reflected off a sample compared with a reference (given as a percentage of the reference spectrum at each wavelength). A reflectance standard is used to set the reference level of 100%. Transmission is similar but compares the light transmitted through a sample, relative to a reference, rather than reflected off it. Typically Reflectance uses a fiber optic probe attached to a light source and a spectrometer, but measurements can be done easily with the Spark, both in free-space or with the SMA Adaptor accessory. Transmission setups are usually the same as Absorbance setups.



A Reflectance Set Up with Probe, Reflectance Standard and Probe Holder

Common Reflectance Applications

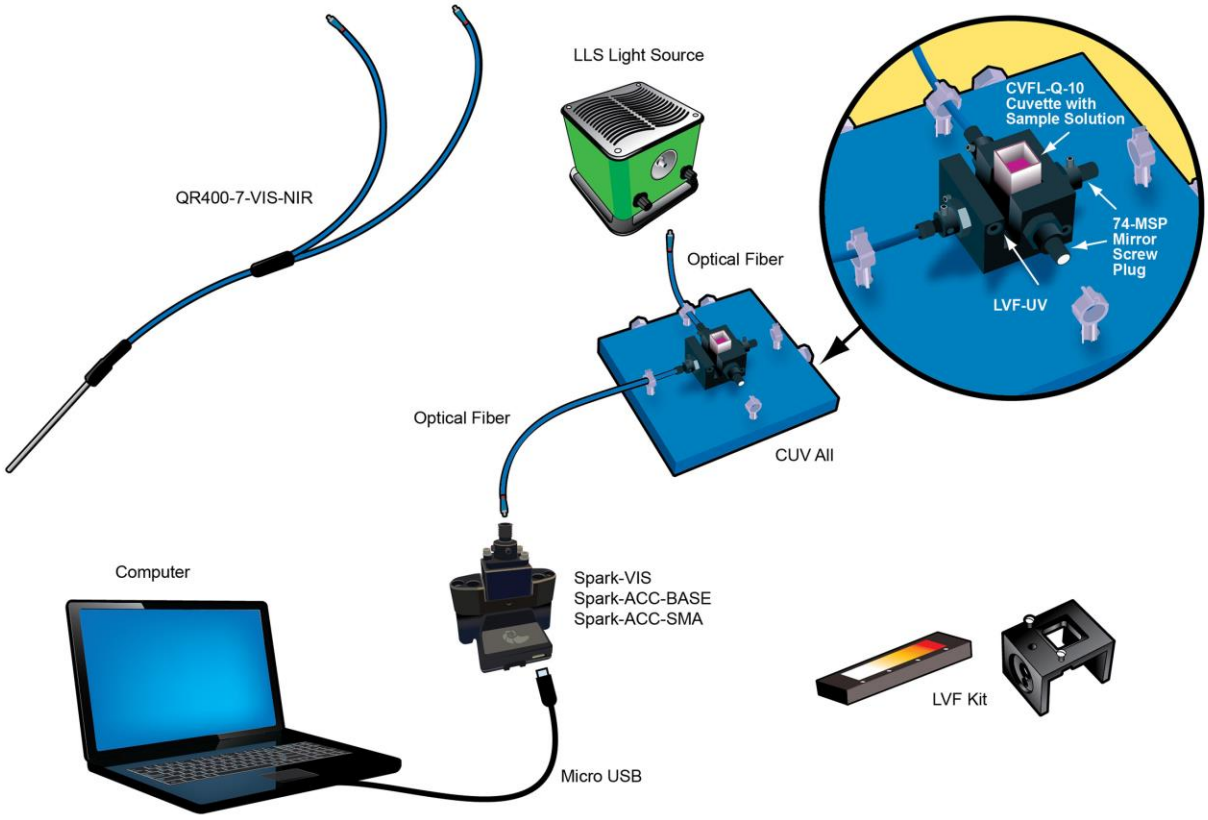
- Diffuse and Specular Color Measurements of surfaces
- Process control for surface quality

Common Transmission Applications

- Turbidity measurements of chemical solutions
- Measuring the transmission efficiency of optics and glass

Fluorescence

A molecule fluoresces if it absorbs light at one wavelength and re-emits light at a longer wavelength. Many biological samples fluoresce under certain lights. In addition, fluorescent molecules are often used to track reaction rates and the presence of other, non-fluorescing compounds. Typically the excitation source is applied at 90º to the sample to minimize light from the excitation source reaching the spectral sensor. Similarly filters are used to block the lower wavelength light from reaching the detector and masking the weaker fluorescence signal. The Spark has a large slit, and therefore has good throughput sensitivity, making it capable of detecting very low concentrations of fluorescent molecules.

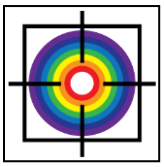


Typical Fluorescence Set Up with an LED Excitation Source at 90º

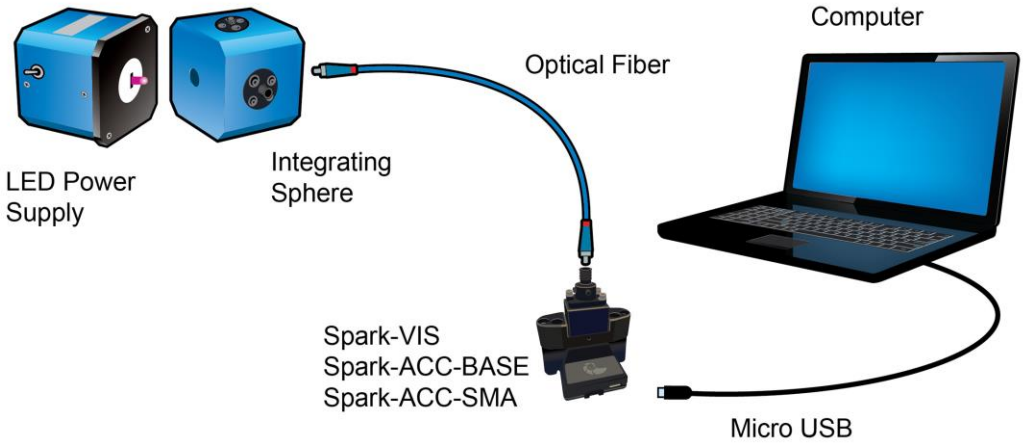
Common Fluorescence Applications

- Identifying proteins using fluorescent tags
- NADH fluorescence
- Remote sensing of chlorophyll

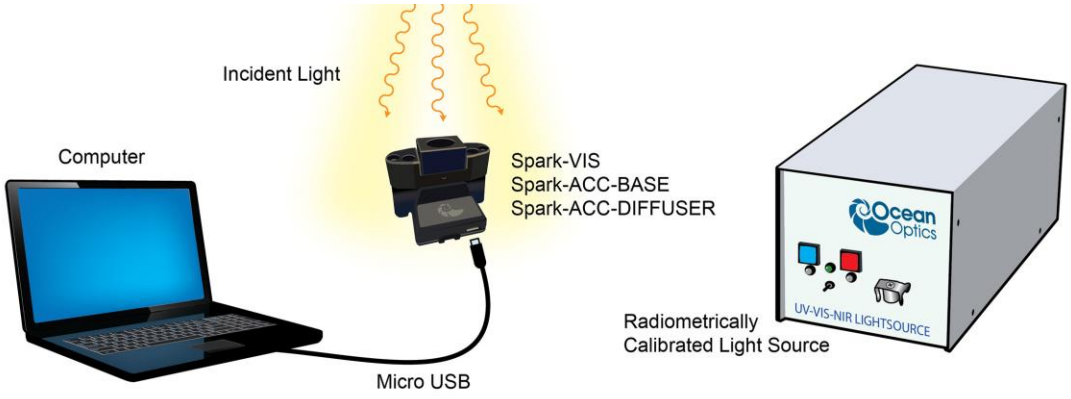
Irradiance



Irradiance is the technique of measuring the total energy of light at a given wavelength, either relative to the spectral output of a known source (relative irradiance) or in absolute units of power or energy (absolute irradiance). This is used widely in light metrology, color measurement and environmental science. Absolute irradiance measurements require an irradiance-calibrated spectral device. This can be done in the factory for some configurations or by using a calibration lamp in the lab or field. Every time a set-up is changed, the device used must be recalibrated. For a more detailed explanation of how to calibrate a device see Chapter 6: Calibration, or contact Ocean Optics. Use the front-mounted diffuser and SMA adapter accessories for irradiance measurements with the Spark.



Typical Relative Irradiance Set-up for Measuring the Light Power Output of an LED Using an Integrating Sphere



Spark with Diffuser Accessory in Free-space Set-up

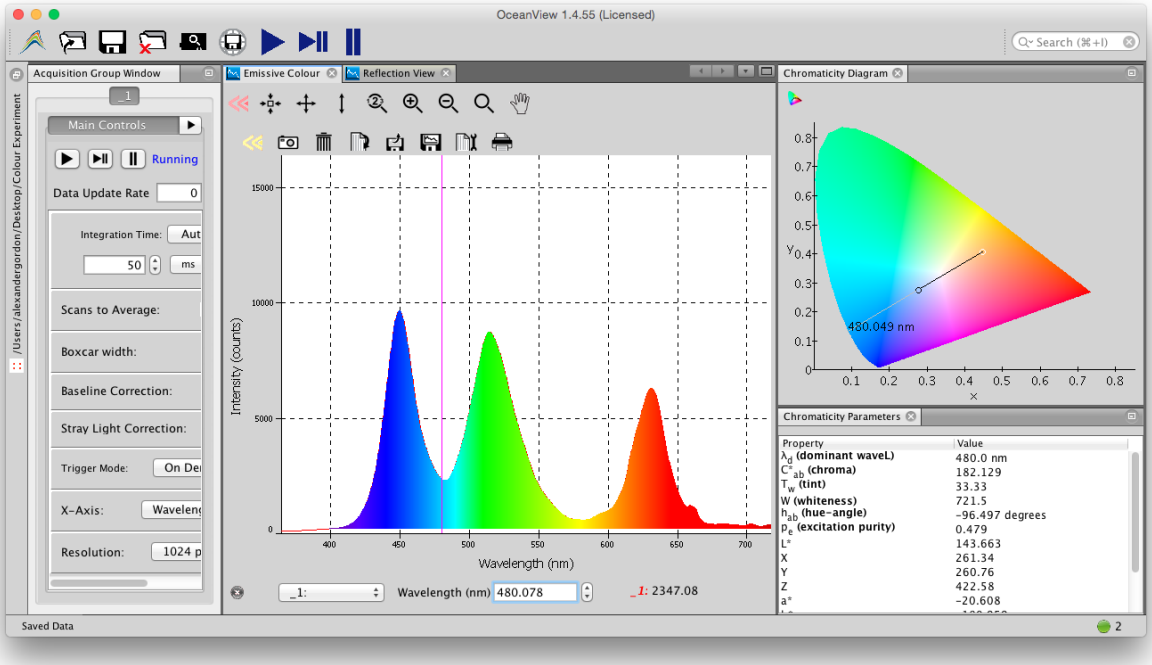
Typical Irradiance Applications

- Measuring the radiant output of lamps and LEDs
- Measuring UV exposure for health and safety

Color

Color measurements are typically taken in reflectance, transmission or irradiance setups; the only difference being that color parameters, such as Chromaticity Coordinates or Correlated Color temperature are calculated from the spectrum. The Spark is ideal for color measurements in a number of experimental setups; it captures a much richer dataset than the RGB filter-diode systems, which base their calculations on only a handful of wavelengths, as the Spark captures data across the entire visible spectrum.

Perceived color is strongly dependent on lighting conditions, as objects tend to appear different colors under different illuminations. With the right lighting, two objects can appear to be identical in color even if the reflected spectral power distributions differ, an effect called metamerism. If the lighting changes, however, the colors will look different. This makes controlled lighting conditions essential in many environments, such as photography studios or store lighting, and accurate color analysis important.



Spark Color Measurement in OceanView

Typical Color Applications

- LEDs characterization
- Lighting monitoring
- Screen color matching

Optimizing Your Setup

Typical Ocean Optics miniature spectrometers split the incident light from the sample into its component wavelengths using a diffraction grating; this requires a finite path length and gives a lower limit to the volume of a grating-based spectrometer. The Spark instead uses a solid-state optical sensor to capture the spectrum. No grating, no path length, no volume!

Owing to the nature of the device, the following should be considered:

- The whole 1 mm x 8 mm aperture on the front of the Spark must be entirely illuminated. This ensures that each detector pixel receives light. The SMA adaptor (SPARK-ACC-SMA-ADAPTOR) projects light from the fiber across the entire aperture. For free space measurements, users must take care with their measurement geometry.
- The spectral response will be sensitive to the angle of incidence of the illumination. Ideally, fix the Spark in place relative to the source. Alternatively use a diffuse source. The ideal set up is a diffuse light source at a normal angle of incidence (perpendicular to the slit). If it is not fixed you may notice small changes in the spectral shape.
- Use the Diffuser accessory (SPARK-ACC-DIFFUSER, sold separately) to help create a diffuse illumination of the entire aperture. See *Spark Accessories* for more information.
- Because the Spark's optical train is not based on diffraction gratings, there is no impact of the grating on the instrument response. However, because of the unique solid state technology, there may be an element of fixed pattern noise (similar to PDA detectors) visible in the raw Quick View mode.
- As with all spectrometers it is important to use a processed mode such as absorbance or relative irradiance to generate results; Quick View mode is there to help you set up the measurement. See the Ocean Optics glossary for more on instrument response and Quick View mode.
- To help minimize stray light, use a light source that only emits across the range of interest. This is true for all spectrometers but especially the Spark because of the unique sensor technology. Visible LEDs are ideal. While the Spark does have filtering to reject wavelengths above and below the range of detection, adding extra filtering at the source may help to reduce stray light further.

You'll find more useful information including a useful glossary of terms on our website at http://www.oceanoptics.com/glossary. For advice on your application, please do not hesitiate to contact our Technical Support team at techsupport@oceanoptics.com.

Chapter 3

Spark Operation with OceanView

Overview

The following sections provide enough information to perform general functions with your Spark-VIS spectral sensor and OceanView software. For more detailed information about OceanView, see the *OceanView Installation and Operation Manual* (see *Product-Related Documentation*).

Launch OceanView

Once you have installed your software and connected your spectral sensor, you are ready to display your measurement data using OceanView. Launching OceanView differs, depending on your operating system and where you have placed your OceanView program files.

For PCs running Microsoft Windows, the default location is Start | Programs | Ocean Optics | OceanView | OceanView.

For Mac computers, the default location is the Applications folder.

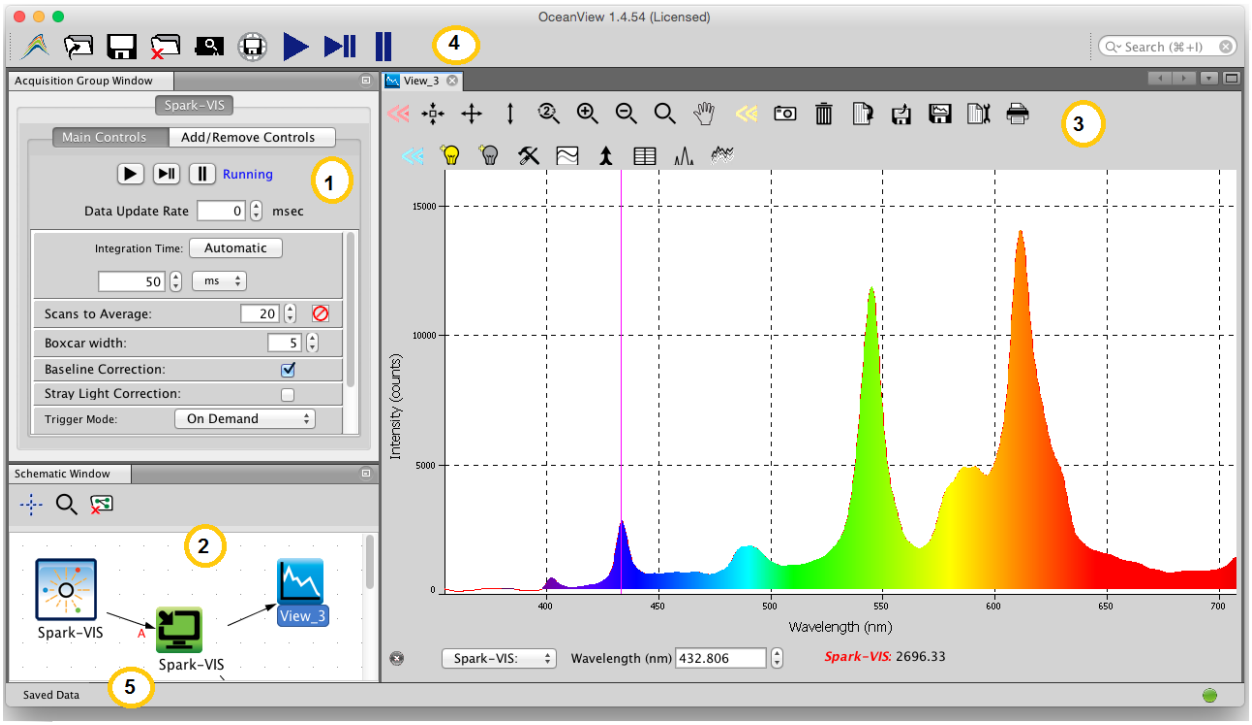
When you first start OceanView, the Welcome Screen appears.

The OceanView Welcome Screen (Version 1.5)

- **Quick View** - Displays the spectrum in Quick View mode showing raw, unprocessed data. This is uncorrected for instrument response vs. wavelength. Quick View shows you a live shot of what the Spark is "seeing." From Quick View you can launch application wizards or construct your own method.
- **Load a Saved Project** - Loads a previously saved project. Click **Restore Last Session** to reload the schematic and views as they were when the software was last closed.
- **Spectroscopy Application Wizards –** Use this function to set up a measurement using simple step-by-step wizards. A large range of applications is available.

OceanView Main Screen

No matter what route you take on start up, you will soon end up on the OceanView main screen. This is where you can set and view measurements, save and load data and save projects.



OceanView Main Screen

1. Acquisition Group Window	Set acquisition parameters such as integration time. Controls the spectral sensor acquisition.
2. Schematic View	Schematic view graphically displays the flow of information from the spectral sensor to the view. Use nodes to mathematically modify the data to create processed measurements. Extremely flexible and incredibly powerful.
3. View Display	Display your data, view, save and display controls, other features such as peakfinder and quick dark & reference.

4. Global Controls	Control all spectral sensors synchronously, save projects, start a new application wizard.
5. Saved Data	Displays data saved in the active save file path. Preview data, store notes and load overlays directly to the active view.

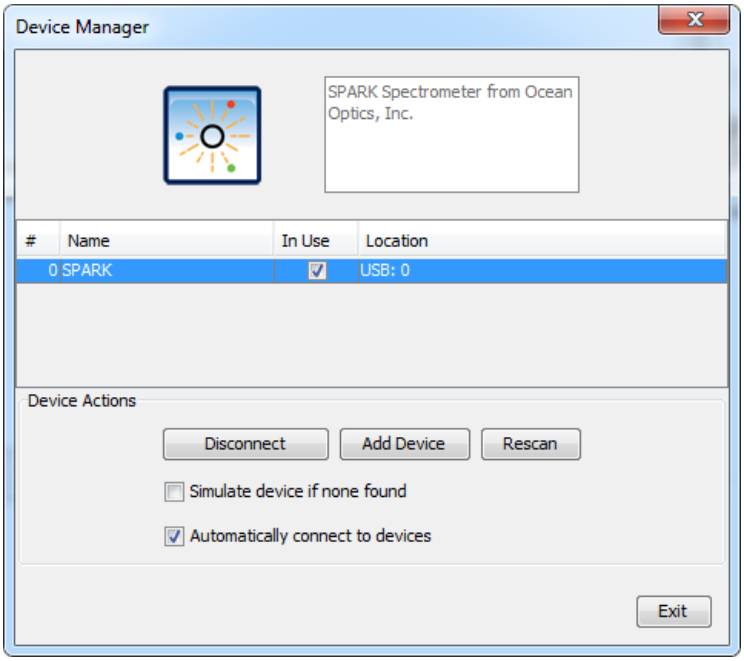
Connect the Spark in OceanView

The Spark should automatically appear when you start OceanView and should start acquiring data with default acquisition parameters. If you do not see a signal or the Spark icon on the schematic you may need to rescan for devices.

► ***Procedure:***

To rescan for attached devices,

1. Click on the Device Manager icon
2. Click Rescan. The Spark should automatically connect.



Set Acquisition Parameters

Acquisition parameters are set using the acquisition group window. The window may appear to be minimized when you first start OceanView, either expand or open a new window from the menu (Window | Acquisition Group). An active acquisition is required for the Acquisition window to appear. Functions available to control in the Acquisition window include the following:

- **Integration Time –** set the integration time, the time over which the detector captures incident light. At the end of the integration time the accumulated signal is read from the detector by the electronics.
- **Averaging –** Signal, especially at low levels, is often significantly impacted by noise. Averaging several spectra together reduces the impact of noise and gives you're a cleaner result. However, at long integration times, averaging can increase the total time of a measurement significantly.
- **Boxcar –** Boxcar is a form of averaging across pixels. It applies a rolling average to multiple adjacent pixels to help smooth the spectral response and reduce the impact of noise.
- **Non Linearity Correction (on or off) –** Detectors do not have a completely linear response. As they approach saturation typically their efficiency reduces. When your spectral sensor is manufactured
- **Stray Light Correction (on or off) –** an advanced user option that allows you to set a 1 or 2 term polynomial correction for stray light correction.

Controls that appear in this window depend on the device model. You can add and remove acquisition controls from this window.

Quick View and Device Response

In **Quick View mode** (formerly **Scope mode**) the spectra that are displayed have an arbitrary y-axis given in counts. This is the raw signal from the detector and is proportional to the voltage induced by the light falling on the detector.

It is very important to realize that this is uncalibrated data and that a counts signal does not represent a particular power or energy from one wavelength to the next. Because the response of the detector is linear, twice the counts at a particular wavelength do indicate that the amount of light at that wavelength has "doubled" (relative to another wavelength). However, a small peak relative to a big peak does not indicate that there is less or more light at a particular wavelength relative to another in absolute terms. To understand the true relationship you need to do a relative measurement (including relative irradiance), or if you want a quantified result, an absolute irradiance measurement.

The relative efficiency of converting light to detector signal varies significantly across the range of a spectral sensor. Many things impact this including the responsiveness of the detector (quantum efficiency) and the efficiency of optical components. Each configuration of a spectral device has a unique response curve, referred to as the instrument response.

Continuous and Single Acquisitions

There are two sets of controls for taking or pausing acquisitions. The set on the Acquisition group window allows you to control each device individually. The set on the top bar is a global control that will allow you to start and pause all devices currently attached.

	Aquire data continuously
	Take a single acquisition and then pause
	Pause all acquisitions.

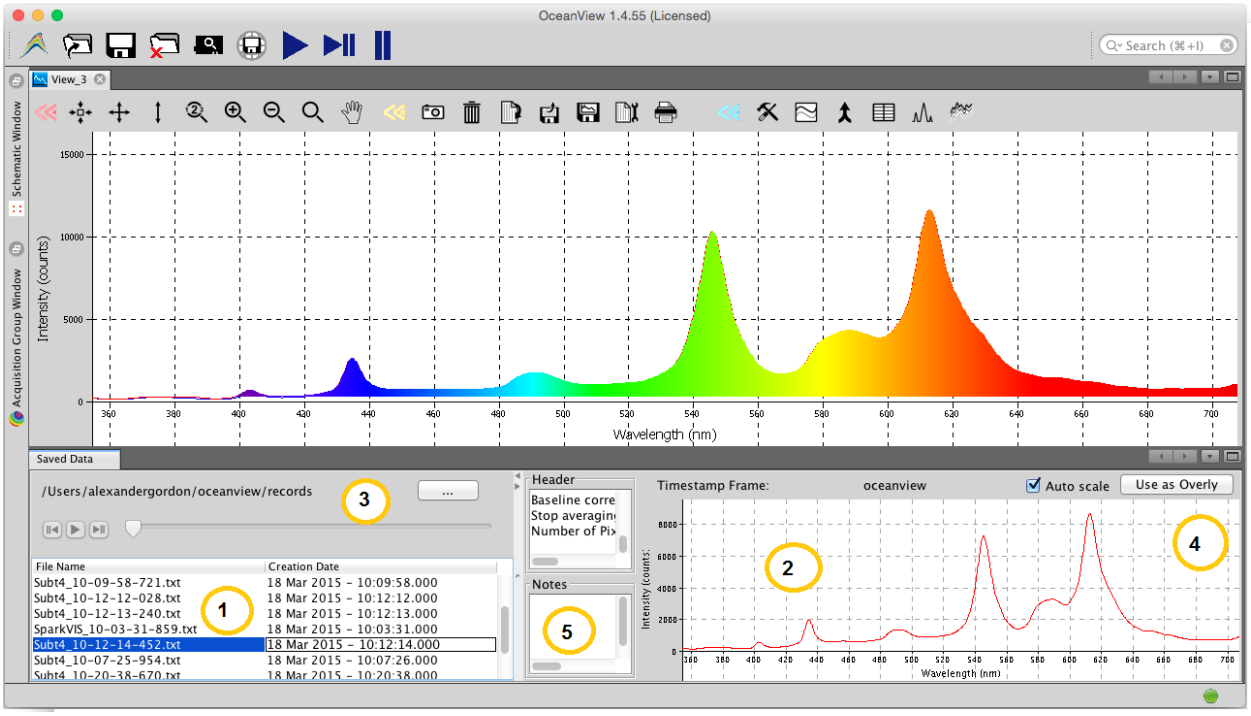
Save Data

	Configure Saving, set saving parameters and file type, file directory and file naming convention. Once selected, the file directory will persist until changed.
	Start saving data. Turns red when save is active. If saving data continuously, click when red to stop saving. Will only activate saving for acquisitions attached to that particular view.
	Global Save. Activates all configured saves across all views. Use to save data from multiple devices at the same time.

By default OceanView will save data as a single "snapshot" acquisition. By configuring the save you can set the save behavior to fit your measurement needs, from single snap shots to a continuous stream of data over time.

Saved Data Panel

The saved data panel lets you see your data as it is saved and preview data. It also makes it simple to add overlays of saved data to your screen.



Saved Data Panel

1. Saved Files	List of saved files currently in the saved directory. Arrange by name or date.
2. Preview	Shows a preview of the saved spectra, time series or appended series saved data can be stepped through acquisition by acquisition using the controls above the saved files list.
3. File Path	Set the file directory.
4. Overlay	Set the previewed spectra as an overlay on the active view.
5. Notes	Enter notes about the saved spectra. Notes are saved with the same file name as a separate .tsv file. These can be viewed or edited with any text viewer such as notepad.

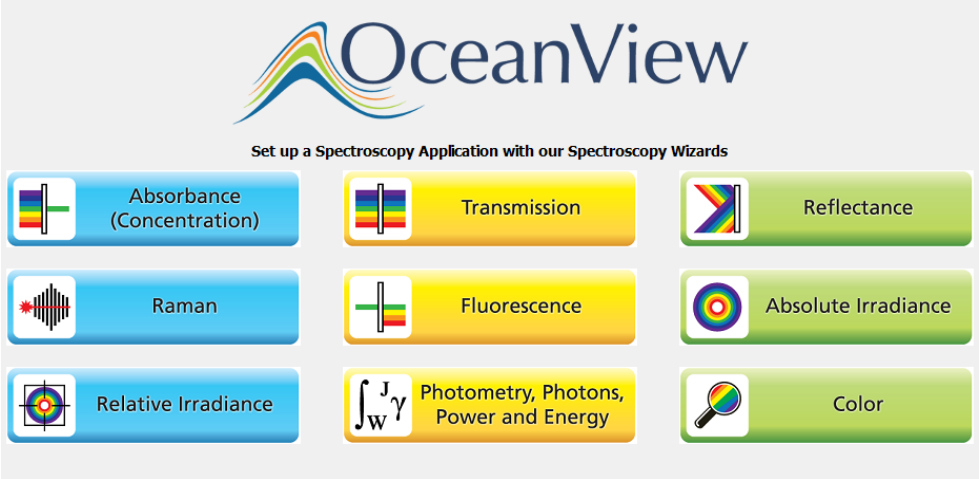
Projects and Methods

OceanView makes it easy to save and load projects and methods. We define a project as a measurement set up made with a particular spectral device. If the software cannot find the device, it will load this as a method and prompt the user to select a substitute device from those selected.

	Click to save a project. Alternatively select *File* | *Save Project* from the menu. Saves all view and schematic parameters to a single ASCII file.
	Load a project or method.

Spectroscopy Application Wizards

	Click this button to set up a measurement using simple step by step wizards. A large range of applications is available.



Application Wizard Window

Dark and Reference Measurements

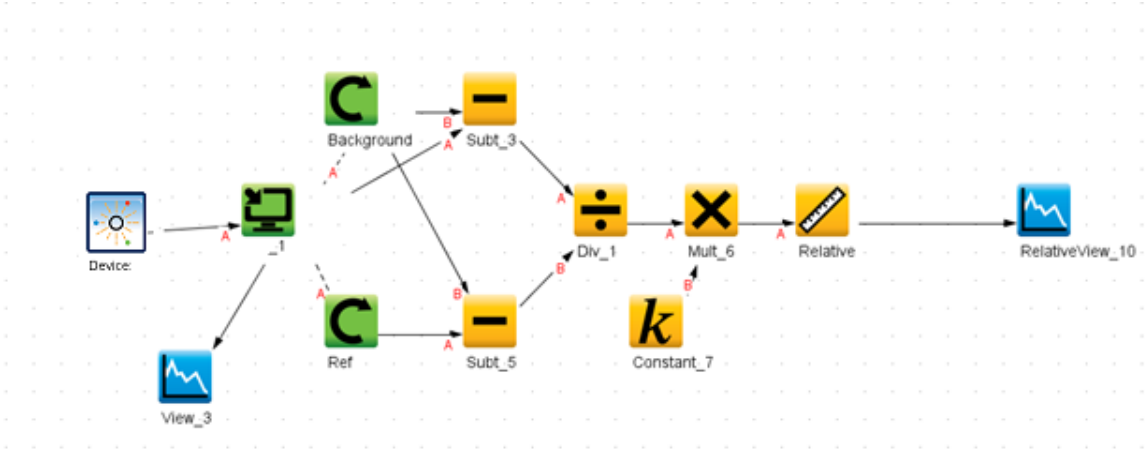
Dark and reference measurements are commonly used in spectroscopy.

- **Dark Measurements –** subtract a background signal from the spectrum. This can be considered the removal of a constant error. Typically this is done when the light source is off to remove any background from the ambient environment, hence the name dark.
- **Reference Measurements –** make the signal relative to the reference. Consider this a normalization of the signal against a reference. Typically this is taken with a reference sample and the light source turned on. This lets you look at the relative spectral change compared to a reference sample.

Most often you will set up your measurement with the reference and dark through the application wizards. The wizards will prompt you to take your reference and darks. Alternatively you can use the quick dark and quick reference features. Once a dark and/or reference measurement has been set, you can update it with the controls on the top bar of the view.

	Quick Reference – click to take a reference and set up a new view. After clicking it will prompt the user to take a dark.
	Quick Dark – click to take a dark measurement and sets up a new Quick View minus dark view.
	Reference – click to update the stored reference measurement.
	Dark – click to update the stored dark measurement.

Schematic View



The schematic view is a graphical interface that allows you to move from device through to processed data. There are a few basic components to consider.

	Devices – each device will appear separately. Right click to open a menu that can generate an acquisition, control a TEC (if applicable) and add other device controls.
	Acquisitions – each device can output one acquisition per detector channel. Right click to open menu.
	Nodes – nodes are the building blocks of the schematic view. They are all various functions that take data in and provide an output. To make a node, right click on the schematic background. Each node can be configured by double clicking on the node. To join nodes press ctrl, click and drag (windows).
	Views- Are a type of view that displays data. To generate a new view right click on the schematic background.

More information about schematic view including detailed descriptions of the available nodes can be found in the *OceanView Installation and Operation Manual* and in the help section of the OceanView software.

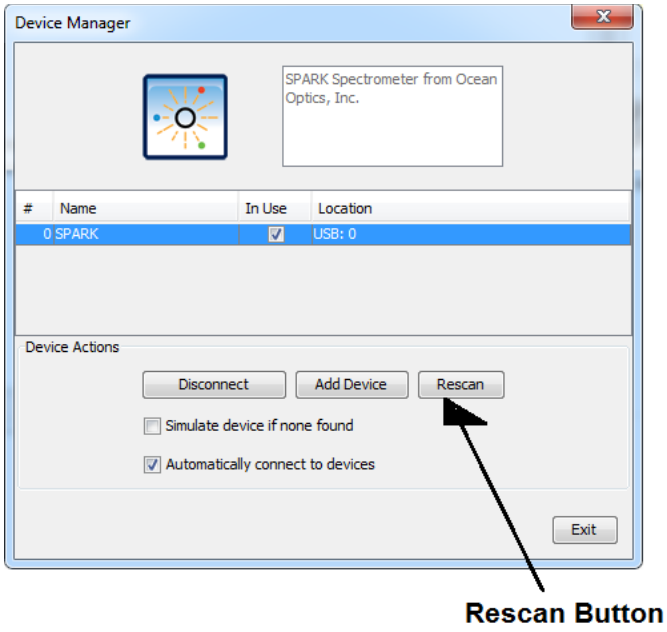
Chapter 4

Troubleshooting

Sometimes things don't quite go to plan; hopefully you'll find some answers below. If not, don't hesitate to contact us and our Tech Support team will leap into action. Some typical questions are answered here. For more information, consult the FAQs on the Ocean Optics website at http://oceanoptics.com/faq/.

I connected the USB cable and started OceanView but I don't see my Spark attached.

Use the Rescan button in the Device Manager to rescan for attached devices. If the device still doesn't appear, try reinstalling the driver files.



I am having trouble installing the drivers, what should I do?

Hardware device driver installation is usually seamless on Microsoft Windows operating systems and should happen in the background when you connect your Spark to a computer with the software installed ***and with a connection to the Internet***. However, some Windows systems require a bit more care when connecting your spectral sensor for the first time.

Note

The driver files may take several minutes to install. The driver will only load if the computer is connected to the Internet, and the time taken to install will depend on Internet connection speed.

If OceanView doesn't recognize your device, you need to manually install the spectral sensor drivers. See your OceanView manual for this procedure. Also see the *Correcting Device Driver Issues* document (see *Product-Related Documentation*).

I'm installing OceanView but I need a product key; where can I find this?

The product key was sent to the contact e-mail on the sales order when you purchased your OceanView license. Contact info@oceanoptics.com for more information. You'll need your sales order number, quotation number, the serial number of the spectral sensor that was purchased with the software, and, if known, the e-mail address under which your product key was created to recover your key.

I connected the Spark to the computer before installing my spectroscopy operating software to install the drivers. What do I do now?

The steps to take to resolve this issue differ, depending on your computer's operating system.

Microsoft Windows Operating Systems

If you connected your Ocean Optics device to the computer prior to installing your Ocean Optics software application on a Windows platform, you may encounter installation issues that you must correct before your Ocean Optics device will operate properly.

Follow the applicable steps below to remove the incorrectly installed device, device driver, and installation files.

Note

If these procedures do not correct your device driver problem, you must obtain the *Correcting Device Driver Issues* document from the Ocean Optics website. See *Product-Related Documentation*.

Remove the Unknown Device from Windows Device Manager

► ***Procedure***

1. Open Windows Device Manager. Consult the Windows operating instructions for your computer for directions, if needed.
2. Locate the **Other Devices** option and expand the **Other Devices** selection by clicking on the "**+**" sign to the immediate left.

Note

Improperly installed USB devices can also appear under the Universal Serial Bus Controller option. Be sure to check this location if you cannot locate the unknown device.

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3. Locate the unknown device (marked with a large question mark). Right-click on the **Unknown Device** listing and select the **Uninstall** or **Remove** option.
4. Click the **OK** button to continue. A warning box appears confirming the removal of the Unknown Device. Click the **OK** button to confirm the device removal.
5. Disconnect the Spark from your computer.
6. Replug the Spark into your computer.

The system should now able to locate and install the correct drivers for the USB device.

7. Plug in the USB device.

The system is now able to locate and install the correct drivers for the USB device.

Apple Mac Operating Systems

Since there are no device files for the Spark in a Mac operating system, you should not encounter any problems if you installed the device before the operating software.

Linux Operating Systems

For Linux operating systems, all you need to do is install the Spark operating software, then unplug and replug in the device. Technically, the driver files for Linux simply give nonprivileged users permission to use newly connected hardware. There isn't any long-term harm to plugging in the device before installing the software.

How do I determine whether my Windows computer is 32-bit or 64-bit?

Errors can occur if you download the wrong version of software (for 32-bit or 64-bit computers). To verify your computer version for most Windows computers, go to the Properties window (under Computer or My Computer). If no version is listed, then your system is a 32-bit. For more information see the Microsoft Frequently Asked Questions at http://windows.microsoft.com/en-us/windows/32-bit-and-64-bit-windows#1TC=windows-7.

Product Upgrades, Repairs and Servicing

Occasionally, you may find that you need Ocean Optics to make a change or an upgrade to your system. To facilitate these changes, you must first contact Customer Support and obtain a Return Merchandise Authorization (RMA) number. Please contact Ocean Optics for specific instructions when returning a product.

Repairs

Sometimes accidents happen! If you need to return your Ocean Optics product for repair, here is what to do:

► ***Procedure***

1. Contact us to speak to an Ocean Optics representative about the problem. If it is determined that the product must be returned, the representative will issue an RMA number.
2. Package your product, ideally in the original packaging, and return it to Ocean Optics, along with the RMA number that you received.

Note

For RMA returns under warranty we will organize and pay for shipping both ways. For accidental damage, you only pay to have the product delivered to your closest Ocean Optics or OOI Distributor Office.

Upon careful examination, we'll advise you with an estimate. When your product is ready, it will be returned to you.

Servicing

To keep your instrument in tip top shape we recommend yearly wavelength recalibration. You can do this yourself if you have appropriate tools or we can do this for you. Contact your local representative to find out more about service availability and cost. We offer the following services:

- Wavelength Calibration for Spark-VIS and Spark-OEM-VIS
- Absolute Irradiance Calibrations for these two models for certain applications

Chapter 5

Technical Specifications

Specifications

Specification	Spark-VIS	Spark-OEM-VIS	Spark-DET-VIS
Optical and Spectroscopic			
Optical Range	380 to 700 nm		
Optical resolution	5 to 10 nm FWHM (~1.4% wavelength)		
Signal-to-noise ratio	1500:1		
Readout noise	3 RMS counts		
Dynamic range for single acquisition[1]	4600:1		
Dynamic range of system[2]	5×10^9:1		
Stray light[3]	~0.3 to 1% across range		
Corrected linearity	< ± 0.5% from 15-95% full scale (2500 - 14000 counts net)		
Wavelength drift	< 0.006 nm/^{o}C		
Electronic			
A/D resolution	14 bit	N/A	
Power consumption	250 mA @ 5 VDC	30 mA @ 5 VDC	
Connector	micro-B USB (power and signal)	12-pin (0.5mm pitch) ribbon cable	14-pin (7 x 2) connector
Detector			
Detector	Panavision ELIS1024 linear silicon CMOS array		

Specification	Spark-VIS	Spark-OEM-VIS	Spark-DET-VIS
Integration time	10 µs to 10 s		
Pixels	1024		
Pixel size	7.8 x 125 µm		
Pixel well depth	~800 ke$^-$		
Sensitivity of Detector	6.74 V/lux.s (at 555 nm)		
Quantum efficiency	60% across spectrum (peak at 675 nm)		
Physical			
Operating temperature	-10 to 60 ^oC		
Storage temperature	-30 to 70 ^oC		
Relative humidity	0 to 85 %		
Aperture size	8 x 1 mm (approx.)		
Dimensions (L x W x H)	53.3 x 36.4 x 19.9 mm	38.4 x 22.6 x 10.2 mm	18.42 x 9.65 x 9.53 mm
Weight	15 g	3.8 g	<1 g
Compliance[AG2][4]			
Electrical	CE, FCC, CISPR 11:2010, EMC 2004/108/EC and EN 61326-1:2013		
Material	RoHS		
Manufacturing	ISO: 9001		

[1] Dynamic range for a single acquisition is a measure of the ratio of full signal to noise.

[2] Dynamic range of the system is the range of the detectable light level and can be thought of as the maximum detectable light level at the minimum integration time divided by the minimum detectable light level at the maximum integration time.

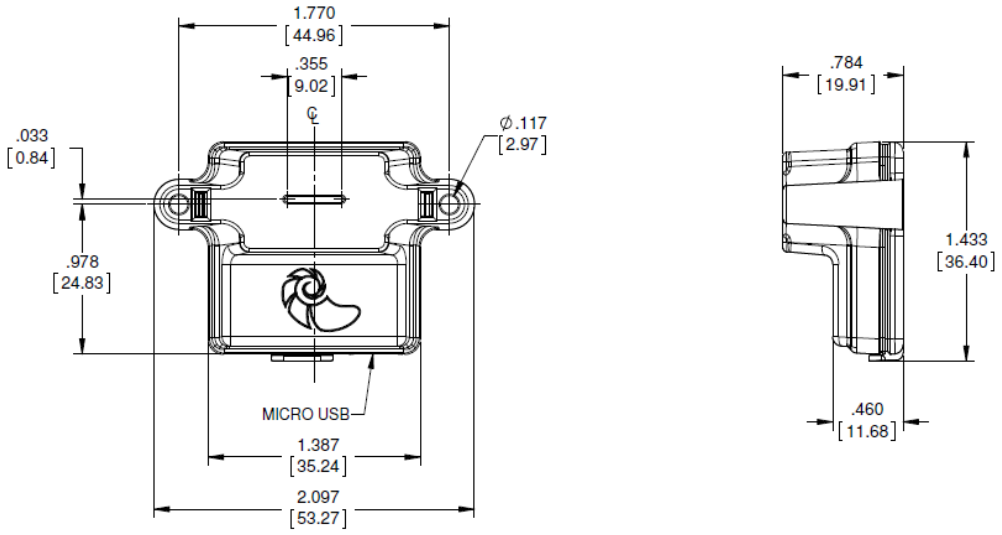
[3] Tested with a broadband illumination source

[4] Contact **info@oceanoptics.com** to obtain copies of certifications.

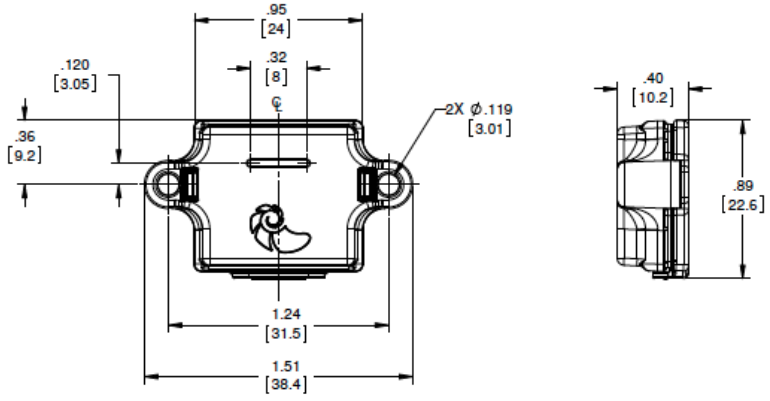
Mechanical Diagrams

Note

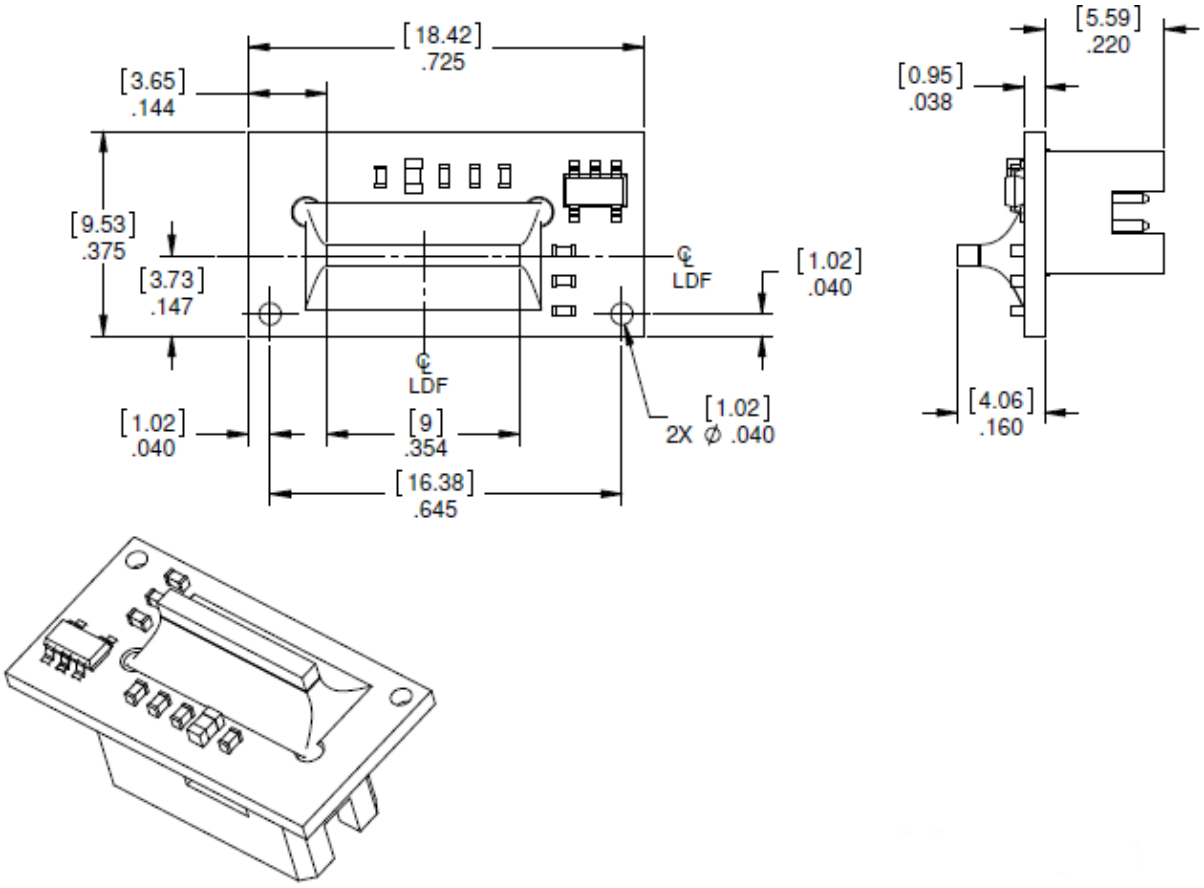
Dimensions are given in inches (and mm in brackets).



Spark-VIS Outer Dimensions



Spark-OEM-VIS Outer Dimensions



Spark-DET-VIS Detector Dimensions (in inches)

Chapter 6

Calibration

Overview

This chapter provides information for performing your own wavelength and irradiance calibrations.

An EEPROM flash memory chip in each Spark-VIS (the user must provide this for other two formats) contains wavelength calibration coefficients, linearity coefficients, and a serial number unique to each individual device. A wavelength calibration sheet is provided with Spark-VIS and Spark-OEM-VIS products – this contains the wavelength calibration coefficients unique to each device. The operating software application reads these values directly from the device, enabling the ability to "hot-swap" devices between computers without entering the coefficients manually on each computer. The Spark-DET-VIS format will need wavelength calibrating by the end user, as the calibration coefficients must be saved to the user's electronics.

Wavelength Calibration

This section describes how to calibrate the wavelength of your spectral sensor. As the wavelength for all units will drift slightly as a function of time and environmental conditions, Ocean Optics recommends periodically recalibrating your Spark.

About Wavelength Calibration

To calibrate the device, the following equation needs to be solved; this shows that the relationship between pixel number and wavelength is a third-order polynomial:

$$\lambda_p = I + C_1 p + C_2 p^2 + C_3 p^3$$

Where:

λ = the wavelength of pixel p

I = the wavelength of pixel 0

C_1 = the first coefficient (nm/pixel)

C_2 = the second coefficient (nm/pixel^2)

C_3 = the third coefficient (nm/pixel^3)

p = the Pixel Number (from 0)

The values for I and the three Cs need to be found.

Wavelength Calibrating the Spectral Sensor

Preparing for Calibration

To recalibrate the wavelength of your spectral sensor, you need the following components:

- A light source capable of producing spectral lines

Note

Ocean Optics' HG-1 Mercury-Argon lamp is ideal for recalibration. If you do not have an HG-1, you need a light source that produces several (at least 4-6) spectral lines in the wavelength region of your spectral sensor.

- A Spark spectral sensor
- An optical fiber (use the SMA-adapter accessory)
- A spreadsheet program (Excel or Quattro Pro, for example) or a calculator that performs third-order linear regressions

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Note

If you are using Microsoft Excel, choose **Tools | Add-Ins** and check **AnalysisToolPak** and **AnalysisTookPak-VBA**.

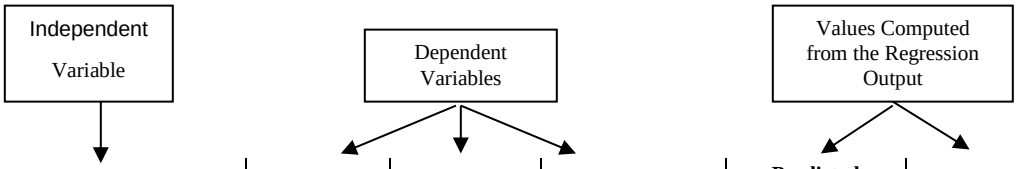
Calibrating the Wavelength of the Spectral Sensor

► ***Procedure***

Perform the steps below to calibrate the wavelength of the Spark:

1. Place the spectral sensor operating software into Quick View (Scope) mode and take a spectrum of your light source. Adjust the integration time (or the A/D conversion frequency) until there are several peaks on the screen that are not off-scale.
2. Move the cursor to one of the peaks and position the cursor so that it is at the point of maximum intensity.
3. Record the pixel number that is displayed in the status bar or legend (located beneath the graph). Repeat this step for all of the peaks in your spectrum.
4. Use the spreadsheet program or calculator to create a table like the one shown in the following figure. In the first column, place the exact or true wavelength of the spectral lines that you used.

In the second column of this worksheet, place the observed pixel number. In the third column, calculate the pixel number squared, and in the fourth column, calculate the pixel number cubed.



True Wavelength (nm)	Pixel #	Pixel # ^{2}	Pixel # ^{3}	Predicted Wavelength	Difference
253.65	175	30625	5359375	253.56	0.09
296.73	296	87616	25934336	296.72	0.01
302.15	312	97344	30371328	302.40	-0.25
313.16	342	116964	40001688	313.02	0.13
334.15	402	161604	64964808	334.19	-0.05
365.02	490	240100	117649000	365.05	-0.04
404.66	604	364816	220348864	404.67	-0.01
407.78	613	375769	230346397	407.78	0.00
435.84	694	481636	334255384	435.65	0.19
546.07	1022	1044484	1067462648	546.13	-0.06
576.96	1116	1245456	1389928896	577.05	-0.09
579.07	1122	1258884	1412467848	579.01	0.06
696.54	1491	2223081	3314613771	696.70	-0.15
706.72	1523	2319529	3532642667	706.62	0.10
727.29	1590	2528100	4019679000	727.24	0.06
738.40	1627	2647129	4306878883	738.53	-0.13
751.47	1669	2785561	4649101309	751.27	0.19

5. Use the spreadsheet or calculator to calculate the wavelength calibration coefficients. In the spreadsheet program, find the functions to perform linear regressions.
   - If using Quattro Pro, look under **Tools | Advanced Math**
   - If using Excel, look under **Analysis ToolPak**
6. Select the true wavelength as the dependent variable (Y). Select the pixel number, pixel number squared, and the pixel number cubed as the independent variables (X). After executing the regression, you will obtain an output similar to the one shown below. Numbers of importance are noted.

Regression Statistics

Multiple R	0.999999831
R Square	0.999999663
Adjusted R Square	0.999999607
Standard Error	0.125540214
Observations	22

R Squared

Intercept

	Coefficients	Standard Error
Intercept	190.473993	0.369047536
X Variable 1	0.36263983	0.001684745
X Variable 2	1.174416E-05	8.35279E-07
X Variable 3	-2.523787E-09	2.656608E-10

First coefficient

Second coefficient

Third coefficient

7. Record the Intercept, as well as the First, Second, and Third Coefficients. Additionally, look at the value for R squared. It should be very close to 1. If not, you have most likely assigned one of your wavelengths incorrectly.

   Keep these values at hand for *Saving the New Calibration Coefficients: USB Mode*.

Irradiance Calibrations

Irradiance calibrations and relative irradiance calibrations quantify the spectra, by translating the signal (incident number of photons) to a known output. This can be either absolute (when using a light source of known output power) or relative (when using a light source of known spectral shape, thereby correcting for instrument response function but not output power). It is used widely in remote sensing, light metrology and anywhere where you wish to characterize the incident light source. Irradiance calibrations are not required for many techniques because these measure the relative signal changes with respect to the sample and a reference, not changes in the light source itself.

You can find out more about irradiance calibration techniques at http://oceanoptics.com/measurementtechnique/irradiance/.

OceanView has wizards that will step you through absolute irradiance and relative calibrations and more information on these is located in the OceanView manual (see *Product-Related Documentation*).

Note

For absolute measurements, it is essential that the lighting and geometry of the setup is ***exactly the same*** when absolute irradiance calibrating the device as when taking a measurement. Any variation from the calibration setup (moving of fibers, light source or device, altering the device acquisition parameters, or altering the background lighting) will nullify the calibration. Please contact our Technical Support team for advice on how to perform an appropriate calibration.

Nonlinearity Correction

A linear device is one in which the output is proportional to the input. For example, if the input is doubled then the output would double. In the case of a spectral device, the output is given in counts and the input in amount of light (photons). We expect doubling the amount of light should double the counts at each pixel (assuming a zero baseline). It may not be easy to accurately double the amount of light by adjusting the light source but it should be easy to double the amount of light collected by doubling the integration time. So, for a constant amount of light, the signal (in counts) should vary proportionally with the integration time. The detector and the A/D converter in a real device will have some degree of nonlinearity, and the non-linearity correction compensates for this.

Nonlinearity correction uses either a 4th order or a 7th order polynomial (a 4th order polynomial can be thought of as a 7th with C5, C6 and C7 coefficients set to zero). Many Ocean Optics devices, including the Spark-VIS format, store the correction coefficients in the device – the Spark-OEM-VIS and Spark-DET-VIS formats will have these coefficients stored on the customer's electronics.

The correction for nonlinearity is performed as follows.

Where:

P: Pixel number starting at 0.

Sp: Scope-mode intensity (uncorrected counts) of a sample at pixel *p*

Dp: Scope mode intensity (uncorrected counts) of pixel *p* for a stored dark spectrum c0, c1, ..., c7: Non-linearity correction coefficients (7th order shown here; stop at c4 for 4th order).

Fp: correction factor for pixel *p*

Rp: Corrected scope-mode intensity of sample at pixel *p*

x: Temporary variable representing the sample minus baseline

For every pixel P in the spectrum:

$x = (Sp - Dp)$

$Fp = c0 + c1x + c2x2 + c3x3 + c4x4 + c5x5 + c6x6 + c7x7$

$Rp = x / Fp$

The resulting spectrum, *R*, is the nonlinearity-corrected spectrum. Typically, the dark spectrum is added back in (thus, the end result is (*Rp+Dp*)) after doing all such corrections so that further spectral math can subtract the dark again without resulting in a negative baseline.

The process for computing these coefficients is somewhat involved. Ocean Optics provides software that can do this calculation (OOINLCorrect). The experiment for deriving these coefficients requires a stable light source that can saturate the Spark across a significant portion of its spectral range (e.g., LS-1). The software changes the integration time steadily and determines the variation in intensity versus time and generates the polynomial coefficients that will make this linear.

Saving the New Calibration Coefficients: USB Mode

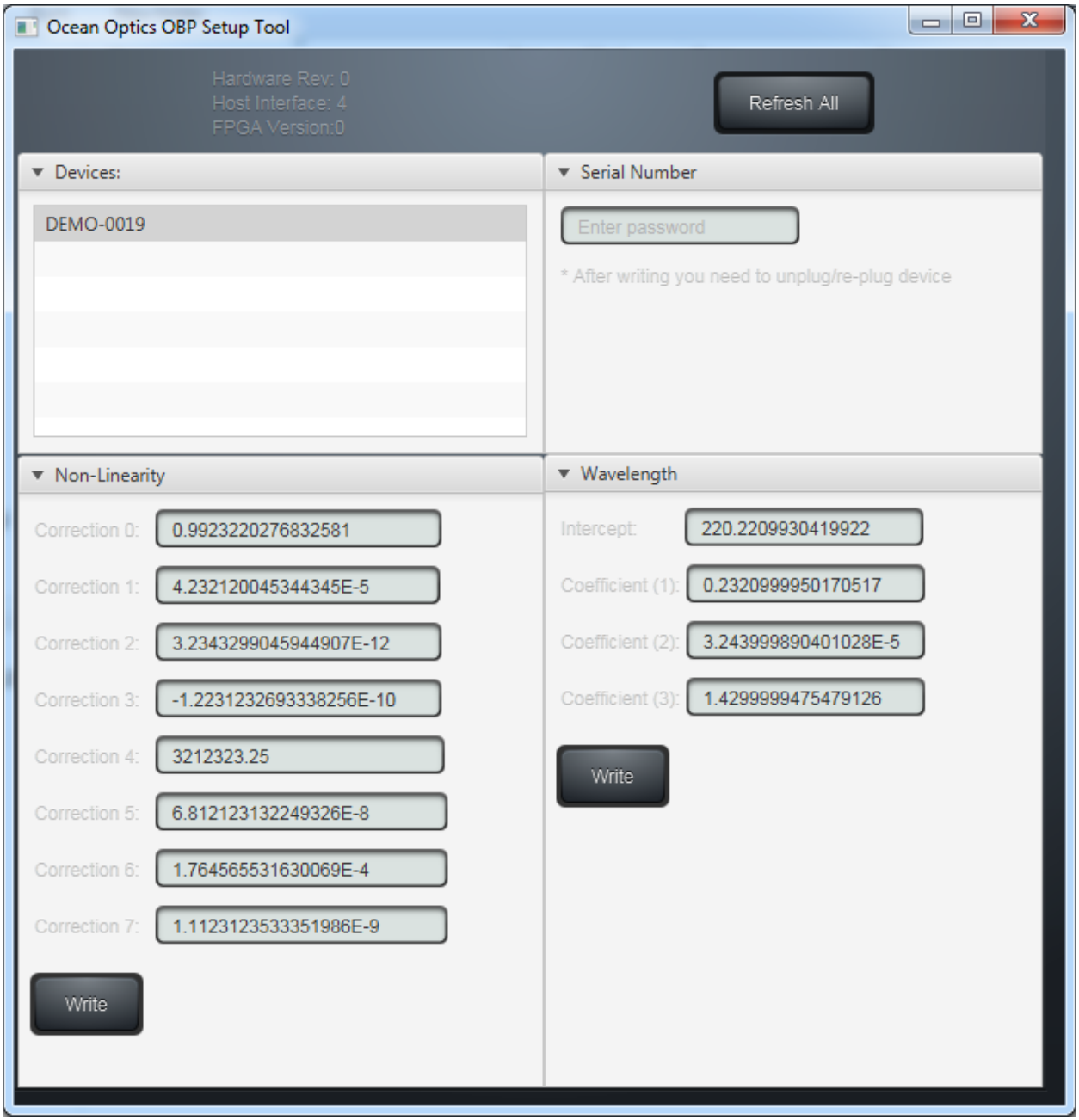
Ocean Optics programs wavelength calibration coefficients unique to each Spark onto an EEPROM memory chip in the Spark.

You can overwrite old calibration and nonlinearity coefficients on the by using the following procedure.

► ***Procedure***

To save wavelength calibration, perform the following steps:

1. Ensure that the Spark is connected to the computer and that you have closed all other applications.
2. Point your browser to http://oceanoptics.com/support/software-downloads/ and scroll down to **Utility Programs**. Select **OBP Setup Tool**.
3. Save the files to your computer and extract them from the zip file.
4. Double-click the file to run the software.
5. Click on the desired Spark device displayed in the **Devices** pane.



6. Click on each of the calibration coefficients displayed in the **Wavelength Coefficients** pane of the USB Programmer screen and enter the new values acquired in Step 5 of the *Calibrating the Wavelength of the Spectral Sensor* section in this appendix.
7. Repeat Step 6 for all of the new values.
8. Click on the **Write Coefficients to Device** button to save the information, and then exit the Utility software.

The new wavelength calibration coefficients are now loaded onto the EEPROM memory chip on the Spark.

Chapter 7

Firmware and Advanced Communications

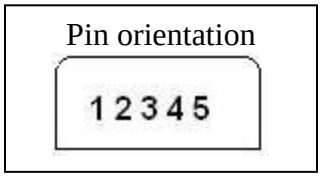
The following chapter contains information on advanced programming and communications. This applies to the Spark-VIS format, which may be programmed through its USB connection.

Electrical Pinout

5-Pin Micro USB Connector

Listed below is the pin description for the Micro-B USB connector.

Pin#	Signal Name	Description
1	V_{USB}	USB power connection (+5V)
2	D-	Data Line -
3	D+	Data Line +
4	N/C	No connection
5	GND	Ground



Reprogramming Mode

The Spark-VIS contains a feature to allow an existing (or failed) application to be replaced with a new one. Refer to the section Upgrading Firmware for more details about how Reprogramming the Application is accomplished.

Start-up Test Function

The Spark will verify its firmware on startup. If the firmware is intact, the device will operate normally. If it appears to be damaged or corrupted, then the device will enter reprogramming mode. This start-up test protects the Spark from being rendered unusable due to failed attempts at reprogramming.

Upgrading Firmware

Upgrading the Application in the Spark can be accomplished using the USB interface. An Application is distributed by Ocean Optics in an OBP file. Upgrading the application is as simple as passing this file to the Spark via one of the aforementioned interfaces. The USB interface will ensure that proper flow-control will take place.

Pixel Binning

Internally, the device has 1024 pixels. As the resolution decreases the effective pixel area increases. When the resolution is set to 512, the photodiodes of pixels 1 and 2 are averaged and output as a single value, pixels 3 and 4 are averaged and output as a single value, and so on. If set to 256 resolution, then pixels 1 through 4 are averaged and output as a single value, 5 through 8 are averaged and output as a single value, and so on.

Because it is full speed and not high speed, 200+ scans per second is difficult. There are tight timing requirements on the USB host in order to get higher than this rate. The Spark will do it, but the host has to be trying to get the data very quickly. On most machines, getting speeds above 200 requires a USB hub to be between the Spark and the computer since the hub attempts to read the data back from the device more often than the machines native full speed USB chips do. The transaction translator of a high speed hub can Increase the Spark throughput by reducing some of the inactive time periods where the Spark is waiting to send its data.

Approximate Maximum Scans Per Second

Binning Mode	USB/ No Hub	USB High-speed Hub
0 (1024)	70	80
1 (512)	120	
2 (256)	160	
3 (128)	250	450

Timing Signals

Timing Constraints

The following table defines the timing limits of firmware-controlled aspects of the Spark:

Parameter	Value	Notes
Minimum integration time	10µs	Integration period error is approximately 1% at 10µs, and less than 0.1% for integration times ≥ 1ms
Minimum cycle time	13.3ms	Cycle time includes integration time, readout, and transmission via USB. This time may only be guaranteed at the minimum integration time.
USB bandwidth	USB 2.0 Full Speed (12mbit/s)	

Communication and Interface

USB 2.0

The primary data interface between the Spark and a host computer is via USB. On the microprocessor, the interface is USB 2.0 Full Speed, which provides 12Mbit/s of bandwidth. The maximum update rate is ~ 75 Hz. The endpoints provided by the USB interface are divided up such that it is possible to request a spectrum and query the status of the device (or provide other commands) while waiting for the spectrum to be returned (see *USB 2.0* for the USB command set).

USB Endpoints (any data query on either OUT will cause a response on the corresponding IN):

EP1 OUT ↔EP1 IN

EP2 OUT ↔EP2 IN

Spark USB Port Interface Communications and Control Information

Overview

The Spark is a spectral sensor that can communicate via the Universal Serial Bus (USB). This section contains the necessary command information for controlling the Spark via the USB interface. This information is only pertinent to users who wish to not utilize Ocean Optics drivers to interface to the Spark. Only experienced USB programmers should attempt to interface to the Spark via these methods.

Note

After start-up or reset, wait 1 second before sending commands to the Spark. The Spark performs measurements at start-up to correct for baseline.

USB Information

Ocean Optics Vendor ID number is 0x2457 and the Product ID is 0x4200.

Protocol Design – Ocean Binary Protocol

The Spark-VIS uses the same binary protocol as the Ocean Optics STS and QEPro spectrometers, which is commonly referred to as Ocean Binary Protocol. The binary command protocol for the Spark spectral sensor has the following design characteristics:

- Provides information so that the host does not need to know the state of the device to read the message.
- Contains a distinct header and footer to fully bracket transfers.
- Provides an abstract interface to the device. All timing is represented in standard units rather than clock divisors. A specific outcome is achieved via a single mechanism.
- Stores calibration information (wavelength, nonlinearity coefficients, etc.) in distinct commands rather than EEPROM slots.

Spark Command Protocol

There are two types of messages in this protocol:

- "commands" that do not return any information
- "queries" that cause the device to return information

When developing a device driver that will communicate with the Spark, the fact that some messages generate a response (including a status indication) and others do not can cause design problems. The simplest approach to creating a driver for this protocol is to have all message types generate a reply. This allows a single message read to be performed after every message write, and if the response indicates an error, then the driver can recover immediately rather than finding the error later when it expects a response to some new query.

The "flags" field in the message header (starting at byte offset 4) has an "acknowledgment (ACK) requested" bit (bit 2). If this bit is set to 1 for every "command", and left at 0 for every "query", then all communications with the Spark will become predictable read/write transactions. The immediate reply allows the host driver to avoid changing its state until it has received confirmation that the last operation succeeded or failed. This makes driver design much easier than the alternative.

It is recommended that an Spark protocol driver implement two functions:

- send_command_to_device() which takes a message type and an optional payload, and returns a simple pass/fail result based on the ACK or NACK flag in the response. This should set the "ACK requested" bit in every message it emits;

- query_device() which takes a message type and optional payload and returns a payload (e.g. a byte array) which can be NULL if the response was a NACK. This must not set the "ACK requested" bit because to do so would generate a spurious ACK in addition to the expected response.

By using these two functions to encapsulate all transfers to the Spark, the programming model is kept very simple.

Message Layout

All multi-byte fields are little-endian (LSB first). Each message in the binary protocol is laid out as follows:

1. A 44-byte header
2. An optional payload
3. A 16-byte checksum block
4. A four byte footer

The header, checksum, and footer are 64 bytes total. For simple messages, the command or response is embedded in the header so only a single packet is required. For more complex messages, the header and footer add a single USB packet as overhead to the transfer.

Header

The message header is structured as follows:

Offset (Bytes)	Field	Size (Bytes)	Valid Values	Notes
0	Start Bytes	2	0xC1C0	Chosen for the following reasons: • High bits set, so not likely to occur in ADC data less than 16 bits wide or message type fields • When concatenated with the tail of a previous message, creates a distinct sequence Note: Do not reverse this byte order.
2	Protocol Version	2	0x0000 – 0xFFFF	Initially set to 0x1000. The host should only send messages known to be supported in the reported version of the protocol. Subsets of this protocol may be specified for other devices using a version less than 0x1000. The device may reject messages with a specified protocol it does not recognize.
4	Flags	2	0x0000 – 0xFFFF	Bits in this flag are assigned as follows: • Bit 0: response to earlier request (message type is set equal to request type). Set by device. • Bit 1: acknowledgment (ACK) if previous message included request for ACK. Set by device. • Bit 2: acknowledgment (ACK) requested. Set by Host.

Offset (Bytes)	Field	Size (Bytes)	Valid Values	Notes
				• Bit 3: negative acknowledgment (NACK). May be sent if previously sent message type is unknown or otherwise invalid. Message type and regarding fields will be set to the type that caused the error. Set by device. Error Number field contains reason for NACK. • Bit 4: exception occurred. Indicates that although the message itself was valid, the device encountered a hardware problem that may have invalidated the result. Error Number will be set to explain, if possible. Set by device. • Bit 5: The message protocol used by the caller is deprecated. If set, an older version of the protocol has been detected (version less than 0.1100). Set by the device.
6	Error Number	2	0x0000 – 0xFFFF	Only set by the device. Indicates whether the previous request was successful. Only set to be non-zero if at least one of the following flags is set: NACK or exception. Only one value can be set, even if multiple errors were detected. Values: • 0: Success (no detectable errors) • 1: Invalid/unsupported protocol • 2: Unknown message type • 3: Bad checksum • 4: Message too large • 5: Payload length does not match message type • 6: Payload data invalid • 7: Device not ready for given message type • 8: Unknown checksum type • 9: Device reset unexpectedly • 10: Too many buses (Commands have come from too many bus interfaces) • 11: Out of memory. Failed to allocate enough space to complete request. • 12: Command is valid, but desired information does not exist. • 13: Int Device Error. May be unrecoverable. • 100: Could not decrypt properly • 101: Firmware layout invalid • 102: Data packet was wrong size (not 64 bytes) • 103: hardware revision not compatible with firmware • 104: Existing flash map not compatible with firmware • 255: Operation/Response Deferred. Operation will take some time to complete. Do not ACK or NACK yet.

Offset (Bytes)	Field	Size (Bytes)	Valid Values	Notes
8	Message Type	4	0x00000000 – 0xFFFFFFFF	Each message type represents a command. See *Message Types*.
12	Regarding	4	0x00000000 – 0xFFFFFFFF	Arbitrary host-defined data. Any response generated by the device will have the same value in its Regarding field. This can be used by the host to match responses to re-que Spark if transactions are split up.
16	Reserved	6		For future expansion.
22	Checksum Type	1	0x00 – 0x01	Valid types: • 0: no checksum (must still provide a block of 16 bytes after the payload, but they can be zero). • 1: MD5 (fully fills the 16 byte checksum block)
23	Immediate Data Length	1	0x00 – 0x10	Total number of bytes used in the Immediate Data field (see below).
24	Immediate Data	16		Provides an alternative to specifying a payload so commands with small operands can fit within a single USB packet. If this field is used, the number of bytes containing valid data must be set in the Immediate Data Length field, and there is no payload. If a payload is used, this field is ignored.
40	Bytes Remaining	4	0x00000000 – 0xFFFFFFFF	Includes the payload, if any, plus the checksum and footer. Payload length must be computed as this field minus the checksum and footer length. Spark may reject any message too long for it to process internally and return a NACK.

The header can be represented as a C struct as follows (assuming that the int type is 32 bits long):

```
struct ooi_binary_protocol_header {
    unsigned char start_bytes[2];     /* = { 0xC1, 0xC0 } */
    unsigned short protocol_version;  /* = 0x1000 */
    unsigned short flags;
    unsigned short errno;
    unsigned int message_type;
    unsigned int regarding;
    unsigned char reserved[6];
    unsigned char checksum_type;
    unsigned char immediate_data_length;
```

```
    unsigned char immediate_data[16];
    unsigned int bytes_remaining;
};
```

Payload

After the standard header, a payload may be provided. The payload contains data required by the given message type. The format of the data within the payload depends on the message type. Note that a payload is not required if operands will fit in the Immediate Data field of the header. The length of the payload must be computed from the Bytes Remaining field in the header, given that the checksum and footer are of a constant length:

Payload length = Bytes remaining – 20

The Spark may populate the Immediate Data field or the Payload as appropriate for the length of the data being returned, regardless of the message type. Host programs decoding this protocol should always be capable of checking both areas in any response.

Checksum

A 16-byte block must appear after the payload (if any) to contain checksum data. This block is required even if no checksum is used (according to the Checksum Type field) or if the checksum does not require the full 16 bytes. The unused parts of the block are for padding to ensure the message length is consistent. This protocol does not support checksums longer than 16 bytes, e.g. SHA, but the intent of the checksum is to detect bit errors, not to prevent tampering or to provide cryptographic assurance.

If a checksum is used, it will be computed starting with the start byte of the header and continuing through the last byte of the payload. The length of the checksum and footer will not be included in the checksum (i.e., for MD5, which includes the total data length as a salt value).

Footer

After the checksum block, a 4-byte footer is provided. The footer has a constant value of 0xC5C4C3C2. Do not reverse the order of the footer.

Message Types

The binary protocol divides up the 4.29 billion possible message types into categories and subcategories in a hierarchy. The most significant bits represent the more abstract categories, while the least significant bits represent subcategories and the commands. The 32-bit message type is split into three blocks, 0xXXX YYY ZZ, as follows:

- XXX: top-level category or feature. 4096 of these may exist.
- YYY: subcategories within the feature. 4096 of these may exist for each category.
- ZZ: specific commands for the subcategory. 255 of these may exist for each subcategory.

The top-level categories (XXX) are initially defined as follows.

- 0x000: General device characteristics

- 0x001: Spectral sensor feature (control of detector and ADC, pixel calibrations and corrections)
- 0x004: Temperature

The subcategories and commands for each of these categories are described in the tables that follow. Input and output data lengths that can be computed from the header (Bytes Remaining field) are not shown. All multi-byte integer types will be returned in little-endian format (least significant byte first). All data will be carried over Endpoint 1or Endpoint 2 IN and OUT unless otherwise stated.

Message Examples

The following is an example of how the Set Integration Time message type (0x001 100 10) can be constructed based on the information provided in this data sheet:

Header

Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
0xC1	0xC0	0x00	0x10	0x00	0x00	0x00	0x00
Start bytes		Protocol version		Flags		Error number	

Byte 8	**Byte 9**	**Byte 10**	**Byte 11**	**Byte 12**	**Byte 13**	**Byte 14**	**Byte 15**
0x10	0x00	0x11	0x00	*x*	*x*	*x*	*x*
Message type (0x00110010)				Regarding (user-specified)			

Byte 16	**Byte 17**	**Byte 18**	**Byte 19**	**Byte 20**	**Byte 21**	**Byte 22**	**Byte 23**
						0x00	0x04
Reserved						Checksum type	Immediate length

Byte 24	**Byte 25**	**Byte 26**	**Byte 27**	**Byte 28**	...	**Byte 39**
x LSB	*x*	*x*	*x* MSB	0	0	0
Integration time (immediate data)				Unused		

Byte 40	**Byte 41**	**Byte 42**	**Byte 43**
0x14	0	0	0
Bytes remaining			

Optional Payload	Byte 44…Byte 59	Byte 60	Byte 61	Byte 62	Byte 63
Not used for this command	Checksum	0xC5	0xC4	0xC3	0xC2
		Footer			

The following is an example of how the Get And Send Corrected Spectrum Immediately message type (0x001 010 00) can be constructed based on the information provided in this data sheet:

Header

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xC1	0xC0	0x00	0x10	0x00	0x00	0x00	0x00
Start bytes		Protocol version		Flags		Error number	

Byte 8	Byte 9	Byte 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15
0x00	0x10	0x10	0x00	*x*	*x*	*x*	*x*
Message type (0x00101000)				Regarding (user-specified)			

Byte 16	Byte 17	Byte 18	Byte 19	Byte 20	Byte 21	Byte 22	Byte 23
						0x00	0x00
Reserved						Checksum type	Immediate length

Byte 24	…	Byte 39
unused		

Byte 40	Byte 41	Byte 42	Byte 43	No payload	Byte 44…Byte 59	Byte 60	Byte 61	Byte 62	Byte 63
0x14	0x00	0x00	0x00		Checksum	0xC5	0xC4	0xC3	0xC2
Bytes remaining						Footer			

Response

Header

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0xC1	0xC0	0x00	0x10	0x01	0x00	0x00	0x00
Start bytes		Protocol version		Flags		Error number	

Byte 8	Byte 9	Byte 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15
0x00	0x10	0x10	0x00	*x*	*x*	*x*	*x*
Message type (0x00101000)				Regarding (user-specified)			

Byte 16	Byte 17	Byte 18	Byte 19	Byte 20	Byte 21	Byte 22	Byte 23
						0x00	0
Reserved						Checksum type	Immediate length

Byte 24 … Byte 39									
unused									
Byte 40	Byte 41	Byte 42	Byte 43	Payload (2048 bytes of spectral data)	Byte 2092…Byte 2107	Byte 2108	Byte 2109	Byte 2110	Byte 2111
0x14	0x08	0x00	0x00		Checksum	0xC5	0xC4	0xC3	0xC2
Bytes remaining						Footer			

General Device Commands

Message Type	Purpose	Input Data	Output Data	Notes
0x000 000 00	Reset	N/A	N/A	Forces a reset of the device. Wait 1 second before reopening the port.
0x000 000 01	Reset Defaults			Clears certain persisted values including default baud rate and pixel binning mode. Once they're cleared, the device will reset and should come up in the factory default mode. Does not erase serial number, bench, alias, calibration, or user strings.

Message Type	Purpose	Input Data	Output Data	Notes
0x000 000 80	Get hardware revision	N/A	Unsigned byte	This value is sensed from the hardware itself. Request has no payload. Reply is a single byte.
0x000 000 90	Get firmware revision	N/A	Unsigned short	Firmware version as binary coded decimal. The same value should be available through the USB descriptor as the bcdDevice field. Request has no payload. Reply is a 2-byte integer (LSB first) of the revision.
0x000 001 00	Get serial number	N/A	String	
0x000 001 01	Get serial number length	N/A	Unsigned byte	Output data is maximum length of serial number in bytes
0x000 002 00	Get device alias	N/A	String	User-defined name for the device (e.g., station number)
0x000 002 01	Get device alias length	N/A	Unsigned byte	Output is maximum length of alias in bytes
0x000 002 10	Set device alias	String	N/A	If string length is 0, alias will be deleted
0x000 003 00	Get number of available user strings	N/A	Unsigned byte	User-defined strings for storing small amounts of arbitrary data
0x000 003 01	Get user string length	N/A	Unsigned short	Output is maximum length in bytes for each user string
0x000 003 02	Get user string	Unsigned byte	String	Input is a string index
0x000 003 10	Set user string	Unsigned byte, String	N/A	Input is string index followed by data. If string data is of zero length, user string will be deleted.
0x000 010 10	Configures Status LED			Byte 0 is reserved and must always be 0x00 Byte 1 is the pattern to drive the LED: 1 = LED will blink in an S-O-S pattern at a high priority (this will not override a POST or hard fault indication, but will override all others)

Message Type	Purpose	Input Data	Output Data	Notes
				2 = LED will fade in and out at a low priority (anything but the solid-on idle pattern will override this) If this byte is anything other than 1 or 2 then the LED will revert to its normal operation.
0x000 FFF 00	Put device in reprogramming mode	N/A	N/A	Causes the Spark to accept an OBP file provided by Ocean Optics.

Spectroscopic Commands

Message Type	Purpose	Input Data	Output Data	Notes
0x001 010 00	Get and send corrected spectrum immediately	N/A	Pixel values (integers)	This returns the intensity of every pixel on the detector as LSB, MSB as soon as it is available. There is no payload in the request. The reply has 2048 bytes of payload. The pixel intensities are corrected for temperature drift and fixed-pattern noise.
0x001 011 00	Get and send raw spectrum immediately	N/A	Pixel values (integers)	This returns the raw ADC output for every pixel on the detector as LSB, MSB as soon as it is available. There is no payload in the request. The reply has 2048 bytes of payload.
0x001 020 00	Get partial spectrum mode			Returns a specification for partial spectrum retrieval (see below). If no specification has been set since the device was started, this will return a NACK indicating "no value available".
0x001 020 10	Set partial spectrum mode			Input is as follows (partial pixel mode formats): Mode 1 (interval spacing): 0x01 00 II II Mode 2 (band): 0x02 00 SS SS II II CC CC Mode 3 (selected) :): 0x03 00 XX XX YY YY ZZ ZZ ... Where: SS SS is the starting pixel index (16 bits, LSB first), II II is the increment (positive or negative, but not zero, also 16-bits LSB first), and CC CC is the total number of pixels (including the starting pixel, cannot be larger than the total pixel count; 16 bits LSB first).

Message Type	Purpose	Input Data	Output Data	Notes
				XX XX is the index of the first pixel to grab, YY YY is the index of the second pixel to grab, ZZ ZZ is the third, and so on, for up to ten pixels. Each pixel index is 16 bits, LSB first. For instance, a payload of 0x03 00 05 00 01 00 09 00 02 00 would get pixels (5, 1, 9, 2) in that order.
0x001 020 80	Get and send partial corrected spectrum			Acquires a baseline-corrected spectrum and returns just the pixels specified by the last partial spectrum specification. If no specification has been set since the device was started, this will return a NACK with a "device not ready" error. Only the specified pixels will be in the response, so the caller must have the specification available to decipher the results. The pixels will be packed into the immediate data portion of the header if they fit; otherwise, they are appended after the bytes_remaining field as an extended payload. Averaging and boxcar are applied if necessary before the values are returned. Partial spectrum modes: 0x0001: Acquire every Nth pixel, starting with pixel 0. The only parameter for this mode is spacing, which is how much to increment the pixel index after each pixel. 0x0002: Acquire a band of pixels. Three parameters are expected: starting pixel index (inclusive), increment (can be positive or negative, but not 0), count (includes a starting pixel, cannot be larger than the total count). The count is a maximum; fewer pixels will be returned if there are not enough pixels in the current binning mode to satisfy this parameter. 0x0003: Acquire pixels by index. This allows up to 10 pixel indices to be given in any order. If any index is invalid for the active resolution, the pixel value for that index will be 0xFFFF. This is to prevent the specification from becoming invalidated by changing resolutions. All parameters (including the mode) are 16-bit values (LSB first), and they are all unsigned except for the increment for mode 2.* The returned values should include any and all averaging and boxcar compensation as specified separately, and the baseline will be compensated as usual.

Message Type	Purpose	Input Data	Output Data	Notes
*Examples: Specification mode 1, spacing of 4 (pixels 0, 4, 8, 12, 16, ...): 0x01 00 04 00 Specification mode 2, starting at pixel 100, every pixel for 10 pixels (100, 101, 102, ..., 109): 0x02 00 64 00 01 00 0A 00 Specification mode 3, for pixels 5, 8, 500, and 375: 0x03 00 05 00 08 00 F4 01 77 01				
0x001 100 10	Set integration time (µs)	Unsigned 32-bit integer	N/A	Input is 4 bytes for time in µs. Order is LSB, …, MSB No reply. The minimum is 10.
0x001 102 80	Get pixel binning factor		Single byte	Returns a single byte indicating the binning mode.
0x001 102 81	Get maximum binning factor		Single byte	Returns a single byte representing the largest binning factor that may be used (3). The minimum is assumed to be zero.
0x001 102 85	Get default binning factor		Single byte	Returns the startup binning factor as a single byte (0 by factory default, may be overridden as an acquisition parameter while device is powered up, and default may also be reset; (see below).
0x001 102 90	Set pixel binning factor			Takes a single byte as the binning factor to use for this bus until the device is reset.
0x001 102 95	Set default binning factor	Zero bytes or single byte		Can take either zero bytes (clearing back to factory default) or one byte (indicating new default mode) as arguments
0x001 105 10	Set trigger delay (µs)	Unsigned 32-bit integer	N/A	Input is 4 bytes for time in µs (minimum 5 µs). Order is LSB, …, MSB No reply.
0x001 200 00	Get scans to average	Unsigned 16-bit integer		Gets the number of scans (1-5000) to average together before returning the spectrum.
0x001 200 10	Set scans to average	Unsigned 16-bit integer, LSB first		Sets the number of scans to average (1-5000). Argument is an unsigned 16-bit integer, LSB first. The spectrum response will still be 16 bits per pixel. The average will round to the nearest integer, with any exact half being rounded up.

Message Type	Purpose	Input Data	Output Data	Notes
0x001 210 00	Get boxcar width	Unsigned byte		Gets the boxcar width being applied to all spectra. Valid range is 0-15.
0x001 210 10	Set boxcar width	Unsigned byte		Sets the boxcar width to apply to all spectra. Valid range is 0-15. Boxcar smoothing will apply to every pixel, even if there are not a balanced number of neighbors on both sides.
0x001 801 00	Get wavelength coefficient count	N/A	Unsigned byte	Request has no input. Reply has 1-byte payload with number of coefficients.
0x001 801 01	Get wavelength coefficient	Unsigned byte	IEEE single-precision	Request has 1-byte input data for coefficient index starting with wavelength intercept at index 0. Reply has 4-byte float (LSB first).
0x001 801 11	Set wavelength coefficient	Unsigned byte, IEEE single-precision	N/A	Input is the order of the coefficient to set (indexing starts with wavelength intercept at index 0), followed by an IEEE single-precision float. No reply.
0x001 811 00	Get nonlinearity coefficient count	N/A	Unsigned byte	Reply has 1-byte output data with number of coefficients.
0x001 811 01	Get nonlinearity coefficient	Unsigned byte	IEEE single precision	Request has 1-byte input for coefficient index to retrieve. Reply has 4-byte float (LSB first).
0x001 811 11	Set nonlinearity coefficient	Unsigned byte, IEEE single precision	N/A	Input is the order of the coefficient to set, followed by an IEEE single-precision float. No reply.

Message Type	Purpose	Input Data	Output Data	Notes
0x001 820 01	Get irradiance calibration	N/A	Up to 4096 bytes	Request has no payload. Reply has up to 4096 bytes (whatever has been stored previously), intended for 1024 x 4-byte floats. If nothing has been stored, the reply will have NACK bit set in flags.
0x001 820 02	Get irradiance calibration count	N/A	Unsigned 32-bit integer	Request has no payload. Reply is a 4-byte integer, LSB first, indicating total number of 4-byte floats to be returned in payload of reply to Get Irradiance Calibration including 0.
0x001 820 03	Get irradiance calibration collection area	N/A	IEEE single precision	Request has no payload. Reply: If a collection area has been set, it's returned as a 4-byte float (LSB first). If not defined, it returns a NACK.
0x001 820 11	Set irradiance calibration	Up to 4096 bytes	N/A	Request has up to 4096 bytes in payload. Sending a zero-length buffer will delete any irradiance calibration from Spark. No reply.
0x001 820 13	Set irradiance calibration collection area	IEEE single precision	N/A	Request has a 4-byte float. Otherwise, no payload (to erase value completely). Sending a zero-length buffer will delete any collection area previously stored. No reply.
0x001 831 00	Get number of stray light coefficients	N/A	Unsigned byte	
0x001 831 01	Get stray light coefficient	Unsigned byte	IEEE single precision	Input is the order of the coefficient to retrieve
0x001 831 11	Set stray light coefficient	Unsigned byte, IEEE single precision	N/A	Input is the order of the coefficient to set, followed by an IEEE single-precision float
0x001 860 00	Spectral sensor get hot pixel indices	N/A	Up to 116 bytes	Request has no data. Reply has up to 58 x 2-byte integers (1 integer per pixel index). If nothing has been stored, the reply will have NACK bit set in flags.

Message Type	Purpose	Input Data	Output Data	Notes
0x001 860 10	Spectral sensor set hot pixel indices	Up to 116 bytes	N/A	Request has up to 58 x 2-byte integers for pixel indices. No reply.
0x001 B00 00	Get bench ID	N/A	String	Request has no input data. Reply has up to a 32-byte ASCII string in output (for bench ID).
0x001 B01 00	Get bench serial number	N/A	String	Request has no input data. Reply has an ASCII string in output (for serial number).
0x001 B02 00	Get slit width microns	N/A	Unsigned 16-bit integer	Request has no input data. Reply is a 2-byte integer (LSB first) for the micron value.
0x001 B03 00	Get fiber diameter microns	N/A	Unsigned 16-bit integer	Request has no input data. Reply is a 2-byte integer (LSB first) for the micron value.
0x001 B04 00	Get grating	N/A	String	Request has no input data. Reply has an ASCII string in output (for grating).
0x001 B05 00	Get filter	N/A	String	Request has no input data. Reply has an ASCII string in output (for filter).
0x001 B06 00	Get coating	N/A	String	Request has no input data. Reply has an ASCII string in output (for coating).

Temperature Commands

Notes

The microcontroller sensor will report values much higher than the detector board thermistor because the microcontroller integrated circuit runs at a higher temperature.

The Spark contains three memory locations for the temperature sensor as follows:

0 = Detector Board Thermistor

1 = Reserved/Internal Use

2 = Microcontroller Sensor Temperature

Message Type	Purpose	Input Data	Output Data	Notes
0x004 000 00	Get temperature sensor count	N/A	byte	Request has no input data. Reply has 1 byte with the number of temperature sensors available.
0x004 000 01	Read temperature sensor	Unsigned byte	IEEE single-precision floating point	Provides the temperature in °C (if calibrated) or raw counts for the sensor (if uncalibrated). Input is 1 byte for the index of the sensor to read. Reply: output is a 4-byte float (LSB first) of temperature in °C.
0x004 000 02	Read all temperature sensors	N/A	Array of IEEE single-precision floating points	Each float is the temperature in °C (if calibrated) or raw counts for the sensor (if uncalibrated). The length of the array will be equal to the number of sensors available. Request has no input data. Reply has a 4-byte floating point (LSB first) for each sensor in the output. Units are in °C.

Chapter 8

Spark-OEM-VIS and Spark-DET-VIS Advanced Use

This chapter is for those users who intend to integrate the Spark-OEM-VIS or Spark-DET-VIS into their own process or product. Please read the previous chapters for instructions on the installation of your Spark-VIS spectral sensor, and general information about the device.

To use these formats of the product, the user must supply driver electronics and software. The Spark-OEM or Spark-DET units must then be connected to these electronics via either a ribbon cable mating socket or a pin output mating socket. The outputs of these two formats of the Spark are both raw analogue signals.

The Spark-OEM format has housing that may be attached to a surface via M2.5 screws. It may also be connected to the Spark Base accessory to interface to all other accessories.

The Spark-DET format is simply an electronic component, so must be integrated onto a electronic board. Housing for this part must be provided by the user.

Details for the ELIS1024 detector and the Murata thermistor components in both devices, and for the two device outputs are given below.

Advanced Product Details

Specification	**Spark ELIS1024 detector**
Supply current	20 mA
Supply voltage	5.0 V
Output voltage at saturation	4.8 V
Output voltage at dark	2.1 V
Conversion gain	3.4 µV/e^-
Output voltage due to dark current	6 mV/s
Sensitivity	6.74 V/lux.s at 555 nm
Clock frequency / pixel read rate	150 kHz

For more information on the ELIS1024 detector, and for acquisition timing charts, see the detector data sheet:

http://www.isgchips.com/pdf/PanavisionSVI_ELIS-1024A-Datasheet.pdf.

All three versions of the Spark contain a thermistor (Murata NCP15XW223J03RC) embedded into the detector board. Please see http://www.murata.com/products/catalog/pdf/r44e.pdf for more information on this part.

Connectivity

The Spark-OEM-VIS device must be connected to the user's driver electronics via a ribbon cable (Molex, part number 21020-0121, pitch 0.5mm). Details for the output pins on the cable are given in the table below.

Pin #	Function	Description
1	TH1	Connected to Thermistor Murata NCP15XW223J03RC which is tied to the Device Ground
2	GND	Device Ground
3	Vout	Buffered Video out signal
4	GND	Device Ground
5	+5Vin	5V Device Supply
6	Shutter	All control and drive signals operated per ELIS 1024 datasheet.
7	M1	
8	M0	
9	RM	
10	Reset	
11	Data	
12	CLK	

The Spark-DET-VIS device must be connected to the user's electronics via a pin connector (Samtec, part number TFML-107-02-L-D-A, with mating connector either SFML-107-02-L-D-A or SFML-107-02-L-D). Details for the output pins on the connector are given in the table below.

Pin #	Function	Description
1	+5Vin	5V Device Supply
2	Vout	Buffered Video out signal
3	Shutter	All control and drive signals operated per ELIS 1024 datasheet
4	GND	Device Ground
5	M1	See pin 3 description

Pin #	Function	Description
6	GND	Device Ground
7	M0	See pin 3 description
8	RM	See pin 3 description
9	Reset	See pin 3 description
10	TH1	Connected to Thermistor Murata NCP15XW223J03RC, which is tied to the Device Ground
11	Data	See pin 3 description
12	CLK	See pin 3 description
13	GND	Device Ground
14	GND	Device Ground

Using the information given above, these two formats of the Spark may be easily integrated into your system. Ocean Optics recommends using a core Spark-VIS unit to test your application before attempting an integration.

For assistance with your integration, please do not hesitate to contact Ocean Optics.

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